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U.S. Department of Energy

# Q3/Q4 2016
# Solar Industry Update

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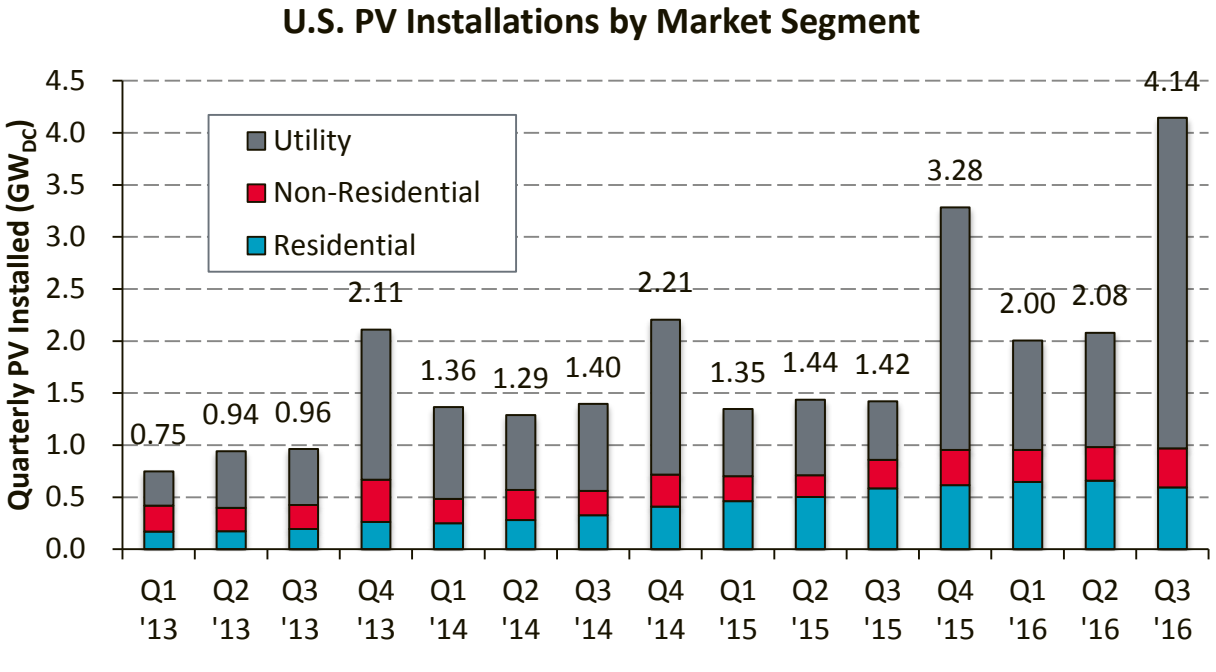
# Executive Summary

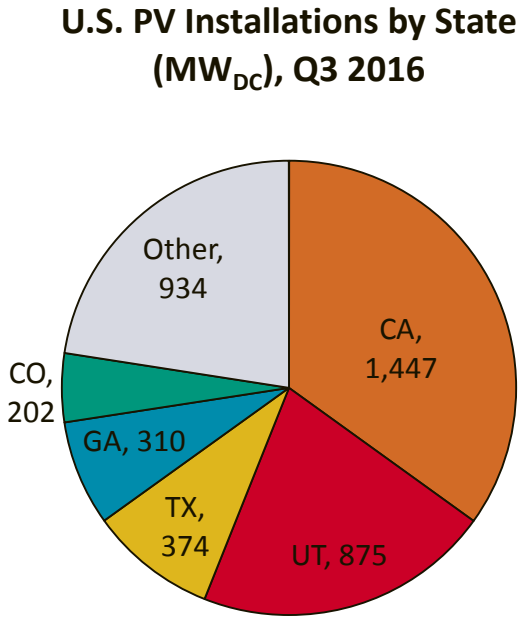
- The United States installed 8 $GW_{DC}$ in the first 9 months of 2016, a 96% increase y/y—34 $GW_{DC}$ cumulative total capacity is now installed in the U.S.
  - Solar represented approximately 34% of all new U.S. electricity deployment in Q1–Q3 2016.
  - 65% of the solar installs in the first 9 months of 2016 were utility-scale PV systems.
  - Relative "weakness" in traditional U.S. distributed solar markets has been offset by the emergence of newer markets.
  - Emerging business practices are driving more solar deployment, such as community solar, corporate PPAs, and PURPA contracts.
- In Q3 2016, residential installation costs (excluding SG&A) for three of the leading firms in the United States were approximately $2/W, with SG&A adding $0.83/W–$0.88/W.
- After several years of relatively flat pricing, modules and components have begun a period of rapid price declines.
  - Analysts have reported a significant drop in module pricing since July 2016, with module quotes between $0.35/W and $0.50/W in the second half of 2016—some in the industry have seen quotes well below $0.40/W for 2017 delivery.
  - Some analysts are expecting prices around $0.3/W and costs around $0.2/W by 2020.
- Eight publicly traded PV companies shipped a total of 6.8 GW in Q3 2016.
  - This is 11% less than Q2 2016 and 5% more than Q3 2015.
- While PV penetration as a share of total net generation for the nation is likely to remain below 3% over the next 5 years, analysts expect certain states to achieve much higher penetration levels.
  - Nevada, California, Hawaii, and Vermont are all projected to have solar penetration rates above 20% by 2021.

# Agenda

- U.S. Deployment
- U.S. Pricing
- Global Manufacturing
- Component Pricing
- Market Activity
- Off-Grid Solar

# U.S. Installation Breakdown



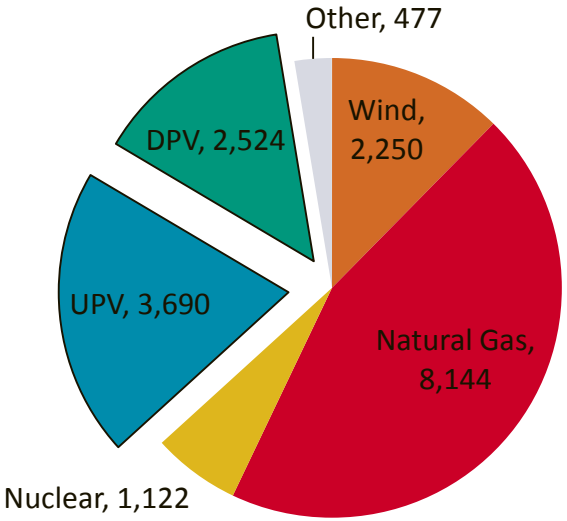




- The United States installed 8 $GW_{DC}$ in the first 9 months of 2016, a 96% increase y/y—34 $GW_{DC}$ total.
  - The United States has installed over 1 GW per quarter over the past 3 years and ~2–4 GW in each of the past 4 quarters.
- Relative "weakness" in traditional U.S. solar markets has been offset by the emergence of newer markets.
  - Offsite commercial solar is expected to account for more than half of all commercial solar installs in 2016.
  - Procurement through PURPA, utilities hedging against natural gas price, and the signature of PPAs priced between $35/MWh and $50/MWh have also helped diversify solar demand and contributed to utility-scale projects deploying 65% of total solar demand in the first 9 months of 2016.

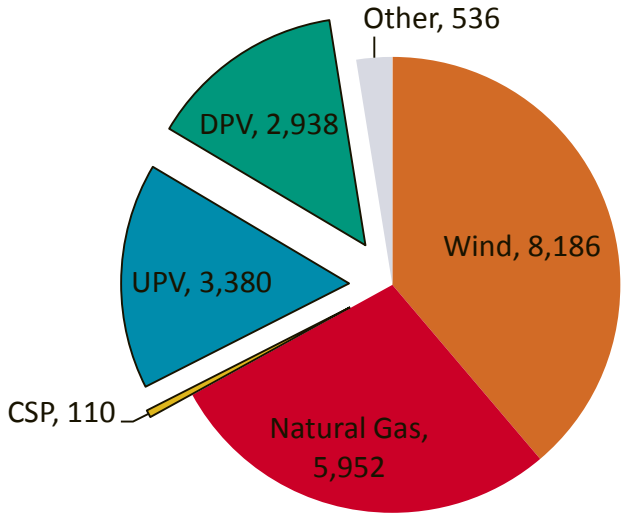
**Source**: GTM Research/SEIA: U.S. Solar Market Insight Q4 2016

# U.S. Generation Capacity Additions by Source 2015 & Q1–Q3 2016

**U.S Generation Capacity Additions, Q1-Q3 2016 (Total 18.2 $GW_{AC}$)**




**U.S Generation Capacity Additions, 2015 (Total 21.1 $GW_{AC}$)**

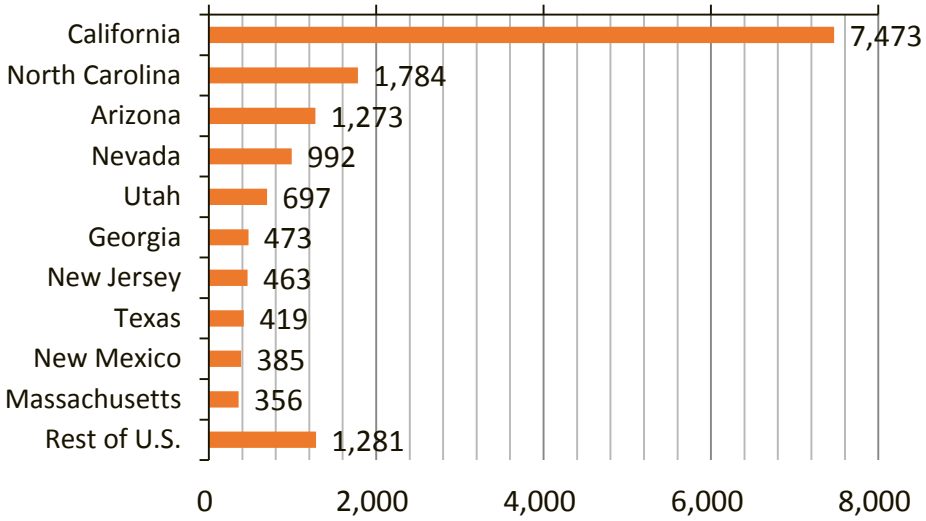



- Solar was the second-largest source of new electricity for the first 9 months of 2016; solar installations in Q4 2016 are also expected to be quite large.
- Solar and wind represented approximately 46% of all new sources of generation, natural gas represented 45%, and nuclear-generating capacity was added to the United States for the first time in 20 years.
- 8 GW of coal and 0.5 GW of oil came *offline.*

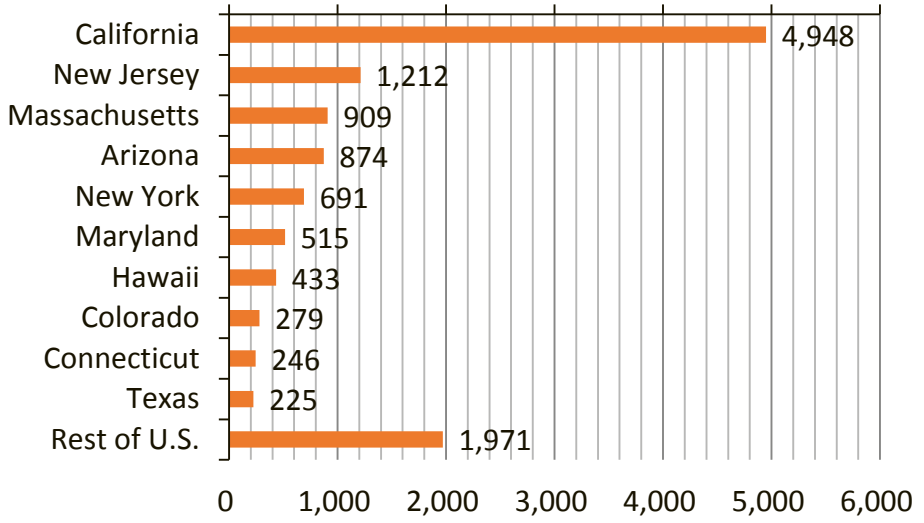
**Note:** The 6.2 $GW_{AC}$ of U.S. solar installations listed in the above graphic in Q1-Q3 2016 differs from the 8 $GW_{DC}$ quoted in other parts of this report due to different data collection and processing by EIA and GTM Research. Additionally, EIA quotes capacity values in Watts-AC, while GTM Research and SEIA quote solar capacity in Watts-DC.
**Source**: EIA, "Electric Power Monthly" Table 6.1

# U.S. Installation Breakdown

**Utility-Scale PV Installed Capacity, Top 10 States, as of Sept.2016**
**Megawatts ($MW_{AC}$)**



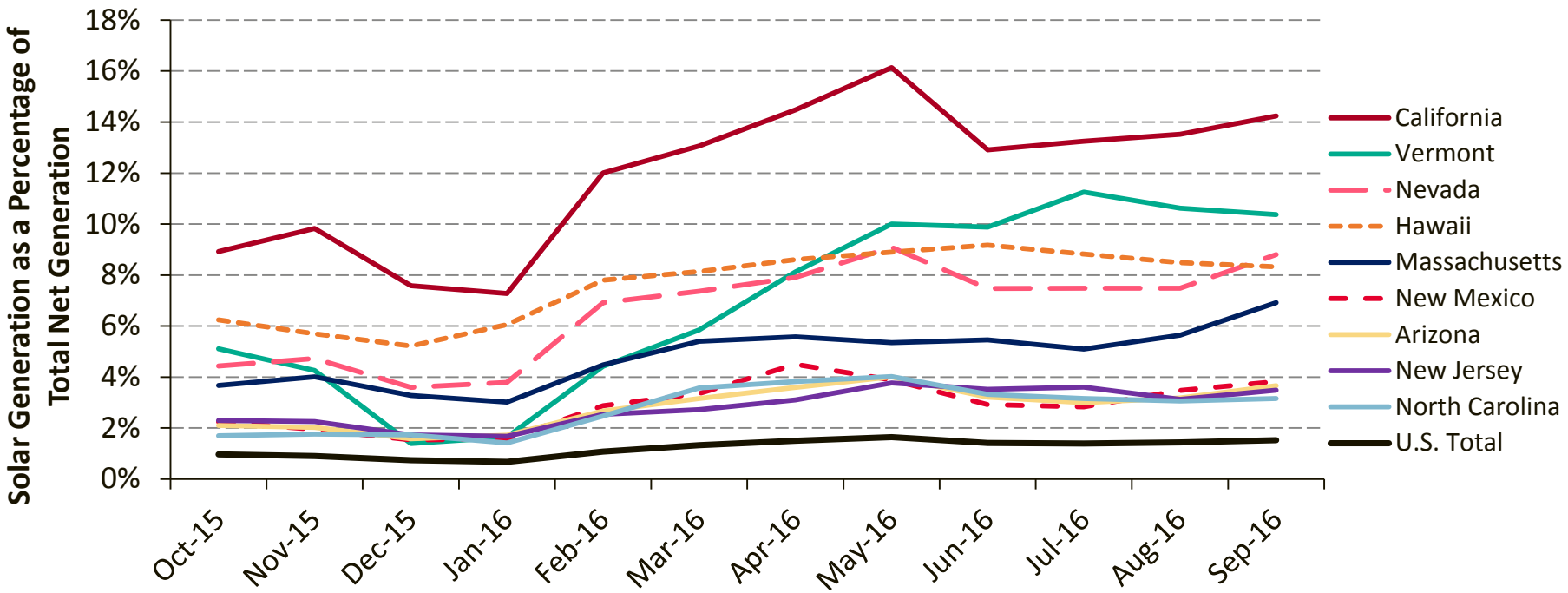

**Distributed PV Installed Capacity, Top 10 States, as of Sept. 2016**
**Megawatts ($MW_{AC}$)**




- At the end of September 2016, there were 27.9 GW-AC of PV systems in the United States.
  - Of the 27.9 GW, 15.6 GW were utility-scale and 12.3 GW were distributed.
- As of September 2016, California system capacity represented 46% of all U.S. PV capacity, leading in both the utility-scale and distributed sectors.
- Half of the top 10 states led in both the utility-scale and distributed sectors, while the other states on the list had less diverse deployment.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note:** EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported.

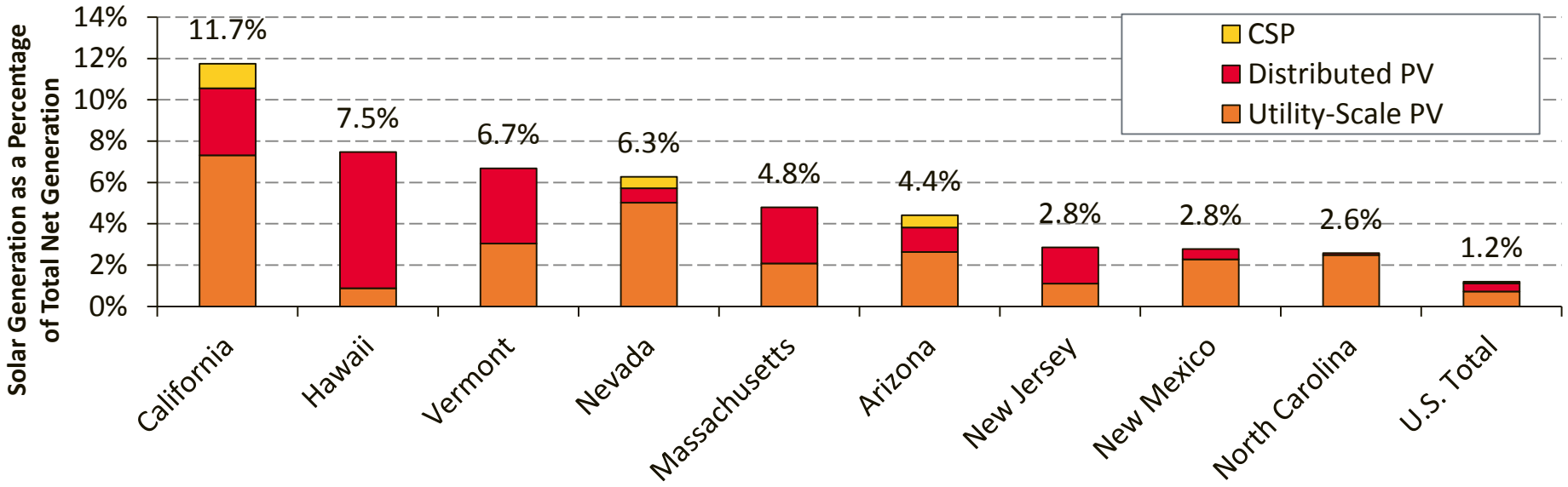
# Solar Generation as a Percentage of Total Generation, Monthly




- From October 2015 to September 2016, solar generated 1.2% of total U.S. electricity generation, peaking in May with 1.6%.
  - During the same time period, solar generated 11.7% in California, also peaking in May with 16.1%.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note**: EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported.

# Solar Generation as a Percentage of Total Generation, Oct. 2015–Sept. 2016




- From October 2015 to September 2016, 4 states produced more than 6% of total net generation from solar and an additional 5 states produced more than 2.5% of total net generation from solar.
- Solar technology contribution varied by state, with Hawaii generating most of its energy from distributed PV, while North Carolina generated the vast majority of its energy from utility-scale PV.
  - During the same time period, CSP generated more than 1% of California's electricity and more than 0.5% in Nevada and Arizona.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note:** EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported.

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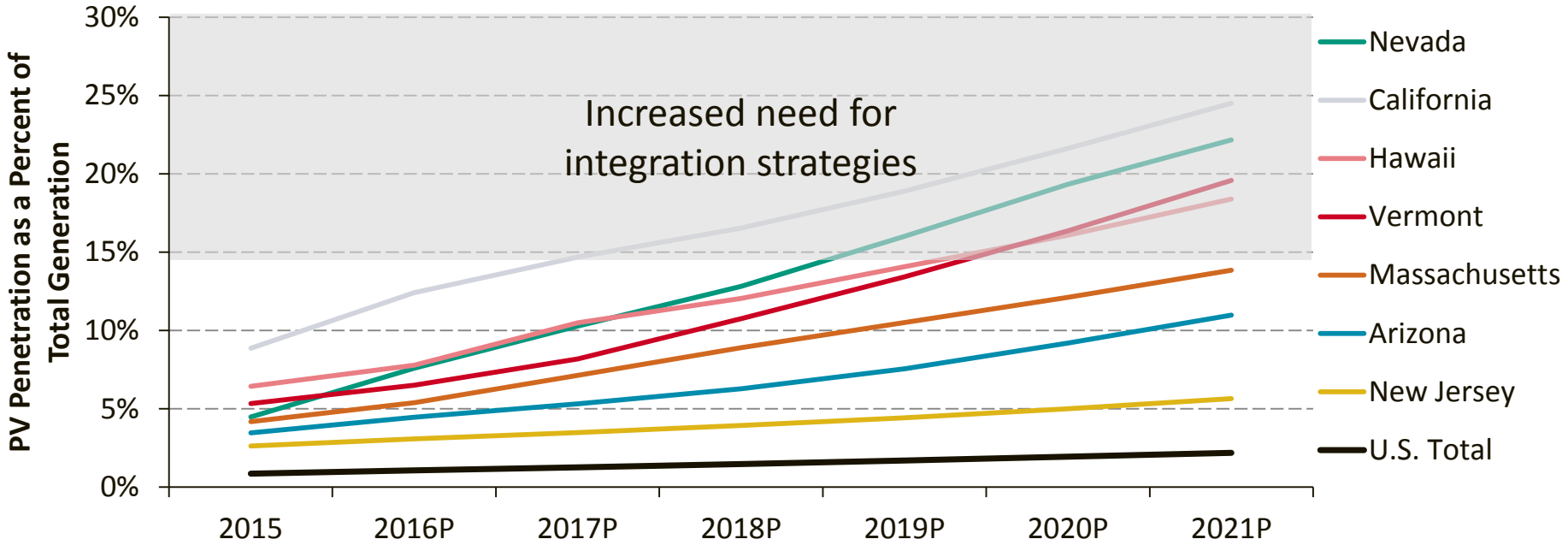
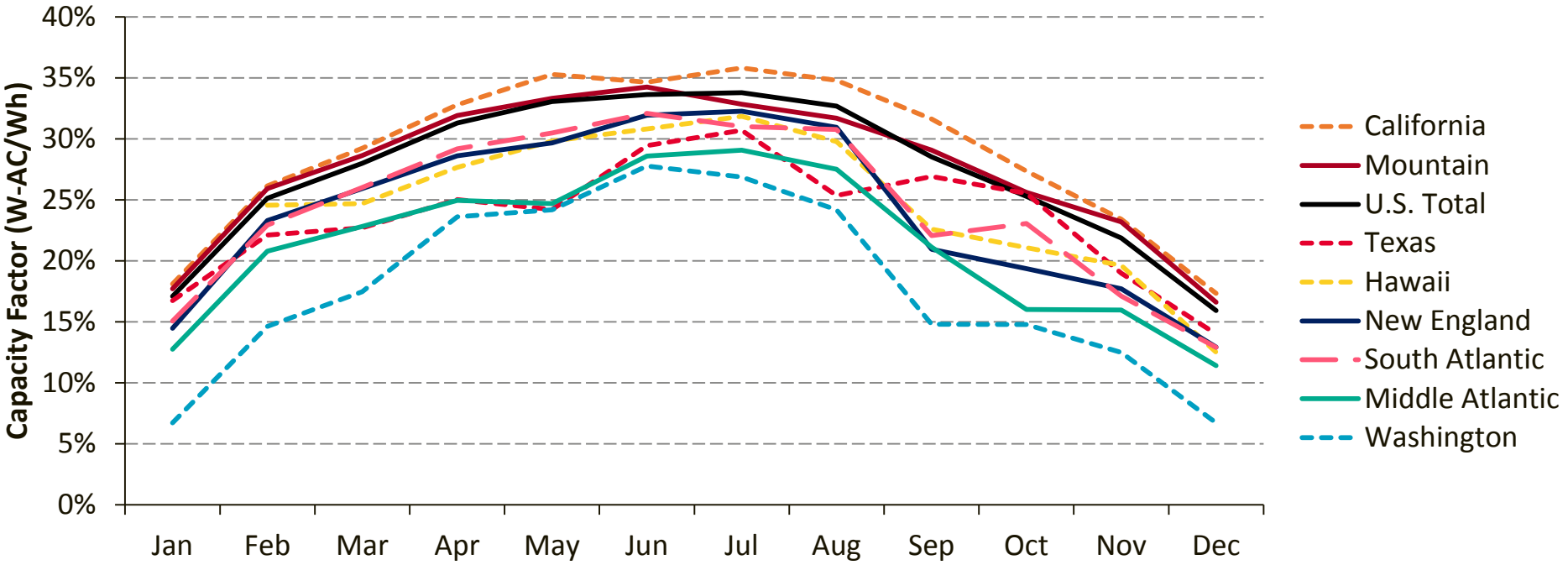
# Solar Generation as a Percentage of Total Generation, Outlook




- While PV penetration for the nation is likely to remain below 3% over the next 5 years, analysts expect certain states to achieve much higher levels.
  - Nevada, California, Hawaii, and Vermont are all projected to have solar penetration rates above 15% by 2021. Some of these states will face larger challenges; for example, Hawaii is not part of a larger interconnection and, therefore, will need to address integration issues at lower levels of penetration than other states.

**Source**: 2015 PV penetration from: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861. Future projections based on the median growth level of each state from: GTM Research / SEIA. "U.S. Solar Market Insight: Q3 2016." September 2016; BNEF, "H2 2016 US PV Market Outlook." December 20, 2016.
**Note**: EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported.

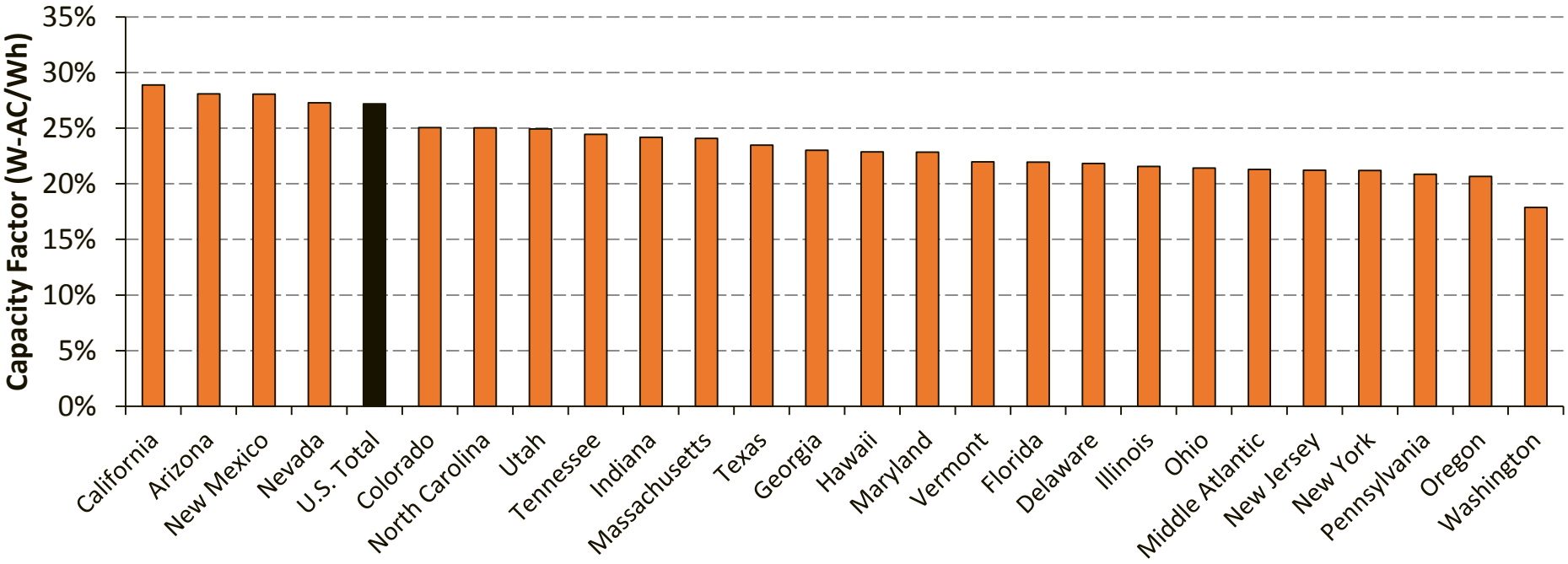
# Capacity Factor of Utility-Scale Systems by Region




- The average capacity factor of utility-scale PV systems varied significantly by season and region.
  - Nationally, the average capacity factor in July (34%) was 112% greater than the average capacity factor in December (16%).
    - This trend varies by region with July production in Washington state 300% greater than in January and December.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note**: EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. Some monthly variability is due to when projects are installed in a given month.

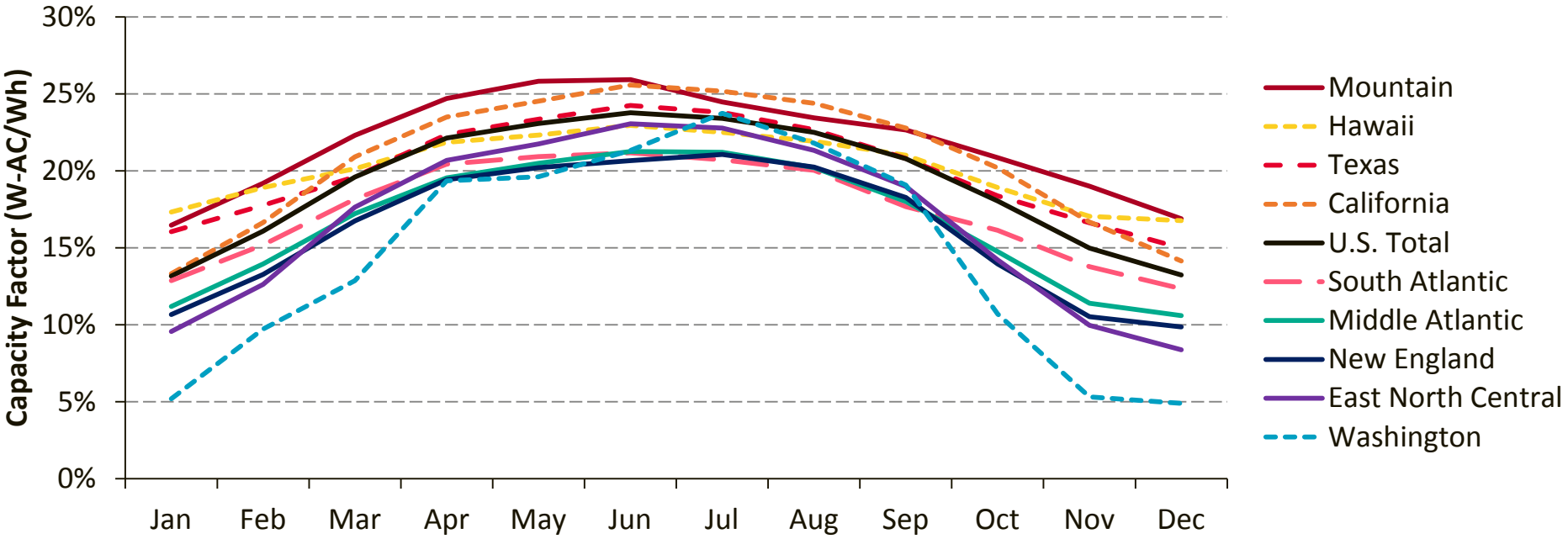
# Capacity Factor of Utility-Scale Systems by State
## Oct. 2015–Sept. 2016




- The average capacity factor of utility-scale PV in California (29%) was 60% greater than the average capacity factor in Washington state (18%).
- The average U.S. utility-scale PV capacity factor (27%) was similar to California and other western states as most systems are installed in that region.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note**: EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. Some monthly variability is due to when projects are installed in a given month.

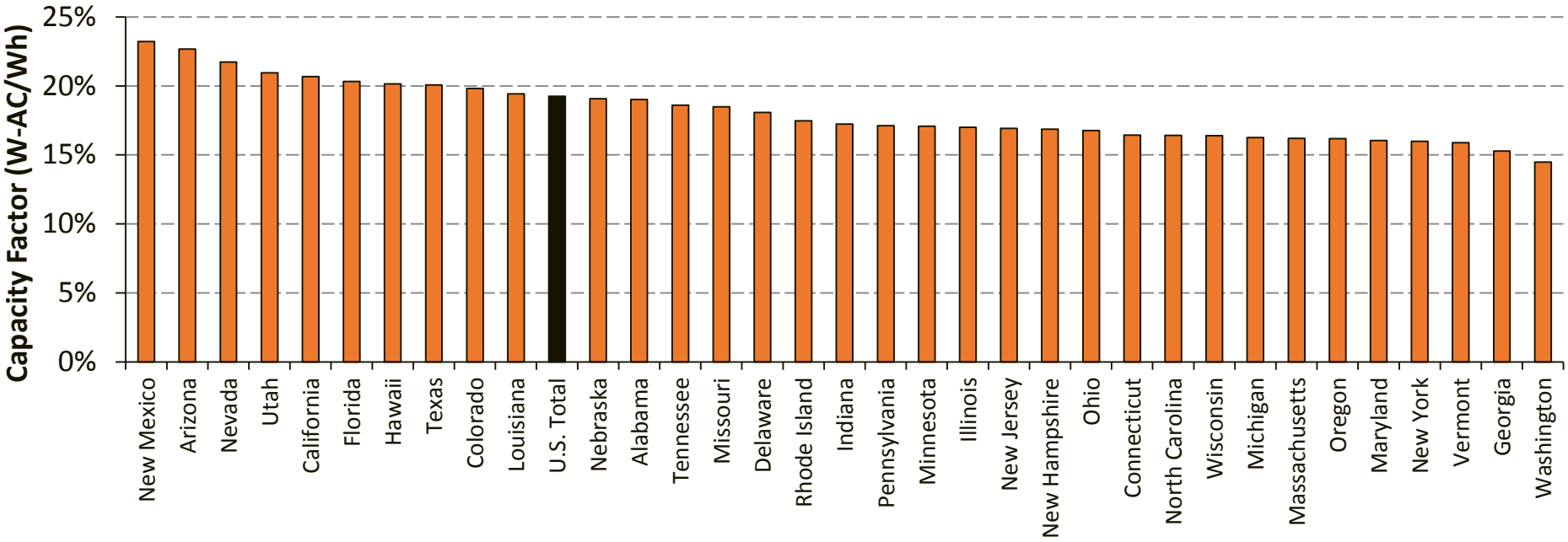
# Capacity Factor of Distributed Systems by Region




- Although less so than utility-scale PV systems, the average capacity factor of distributed PV systems also varied by season and region.
  - The average capacity factor of California (21%) was 43% greater than the average capacity factor in Washington state (14%).
  - Nationally, the average capacity factor in July (23%) was 77% greater than the average capacity factor in December (13%).
    - This trend varies by region with July production in Washington state 380% greater than in January and December but only 34% greater in Hawaii.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note**: EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. Some monthly variability is due to when projects are installed in a given month.

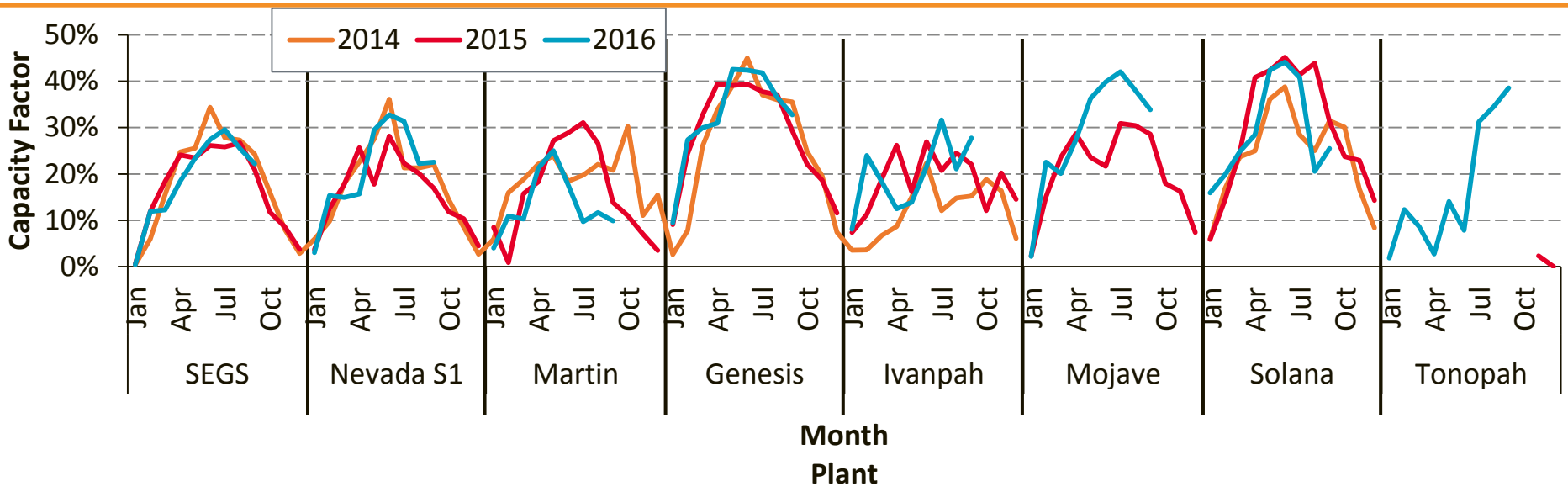
# Capacity Factor of Distributed Systems by State
## Oct. 2015–Sept. 2016




- Although less so than utility-scale PV systems, the average capacity factor of distributed PV systems also varied by state.
  - The average capacity factor of California (21%) was 43% greater than the average capacity factor in Washington state (14%).
- The average U.S. distributed PV capacity factor (19%) was similar to California and other western states as most systems are installed in that region.

**Source**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.
**Note**: EIA monthly data for 2016 is not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. Some monthly variability is due to when projects are installed in a given month.

# Capacity Factor of CSP Projects




- In the first 9 months of the year, U.S. CSP plants have produced roughly the same energy as in previous years, given the DNI variability each month and year.
- The two exceptions are:
  - Mojave, which produced 41% more energy from May to September 2016 than it did during the same period in 2015.
  - Tonopah, which began producing energy in November 2015 and continued to improve production through 2016.

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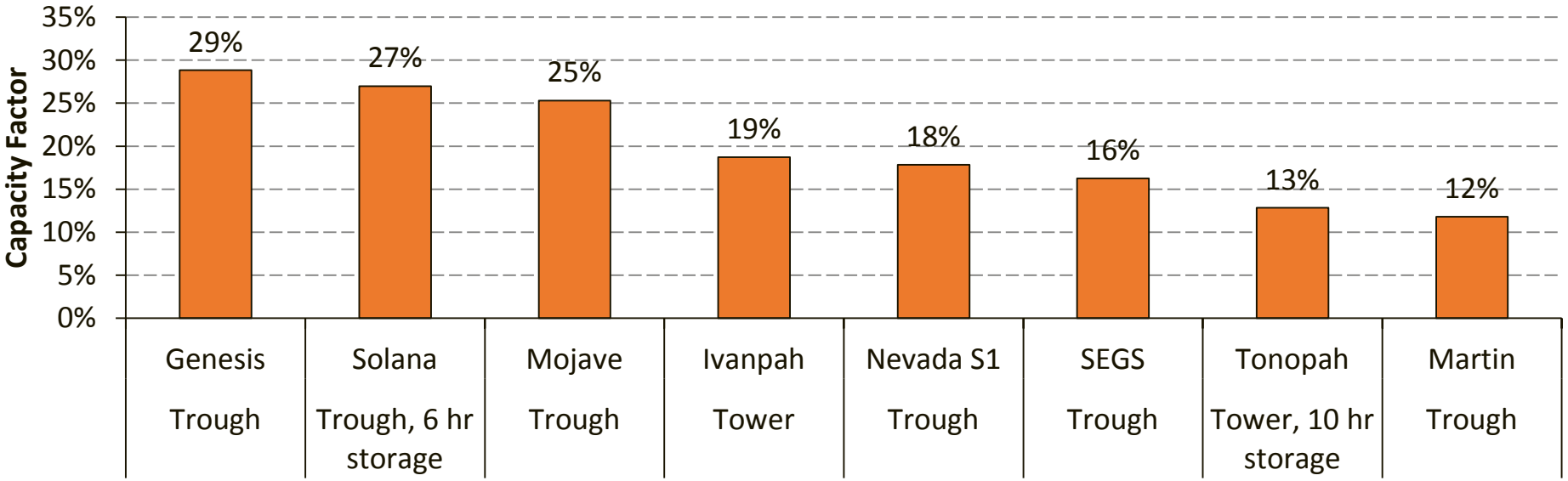
**Source**: System AC nameplate capacity is sourced from EIA Form 860. Monthly system electricity production is sourced from EIA Form 923.

# Capacity Factor of CSP Projects

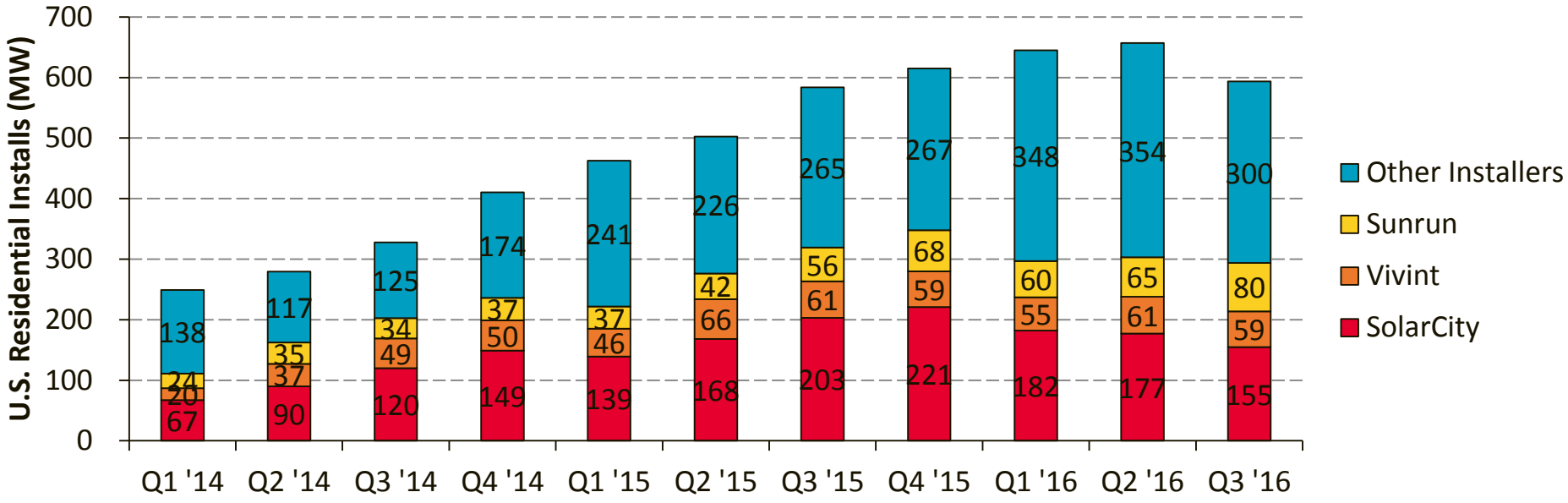
## Oct. 2015–Sept. 2016




- In general, CSP projects installed in the past 3 years have higher capacity factors than older plants.
- Capacity factor can vary widely depending on individual system design. Storage and higher temperatures should increase a plant's capacity factor.
  - To date, "power towers" (with higher temperatures) and "molten-salt storage" have not necessarily translated into higher capacity factors.
  - CSP plants often need operating time to determine how to run optimally, particularly for newer technologies.

**Source**: EIA Form 923.

# SolarCity, Vivint Solar, and Sunrun Market Share




- Residential solar installations are dominated by a few installers, compromising approximately 47% of the market in Q1–Q3 2016 compared to 53% in Q1–Q3 2015.
  - The residential market grew by 22% in the first 9 months of 2016 compared to the same period in 2015; however, Q3 2016 was relatively flat y/y and down Q/Q.
- Q3 2016 did not experience the H2 growth for integrated installers as in previous years.
  - Growth by Sunrun was offset by lower installations by SolarCity.
- These companies are also diversifying their finance offerings.
  - Loans and cash purchases made up 23% of SolarCity's Q3 2016 residential bookings and 29% of September bookings.

**Sources**: Corporate filing, GTM Research/SEIA Q4 2016

# Third-Party Ownership

- In December 2016, EIA reported that 44% of residential PV systems and 11% of commercial and industrial systems are owned by a third party—or 30% of all distributed PV systems.
- These numbers are in contrast to statistics previously reported by other sources:
  - Lawrence Berkeley National Laboratory (LBNL) reported in *Tracking the Sun IX* that between 2012 and 2015, TPO represented 62%–66% of the residential market, 22%–38% of the non-residential market (≤500 kW), and 38%–46% of non-residential systems (>500 kW).
  - GTM Research similarly reported that from 2012–2015, TPO represented 62%–72% of the residential market and will likely represent a little over half of the market in 2016.
    - GTM Research also estimated that 6.9 GW of third-party owned distributed PV systems were installed from 2011 through Q3 2016, compared to EIA's estimate of 3.7 GW, including TPO systems before 2011.
  - It should be noted that well over 75% of distributed PV installations occurred after 2011.
- Each source has different data from which it bases its statistics, as well as different definitions of market sectors—additionally, these numbers often change as more data are collected.

**Sources**: EIA (12/07/16); GTM Research, "U.S. Residential Solar Financing 2016–2021" (November 2016); LBNL, "Tracking the Sun IX (September 2016).

# Agenda

- U.S. Deployment
- U.S. Pricing
- Global Manufacturing
- Component Pricing
- Market Activity
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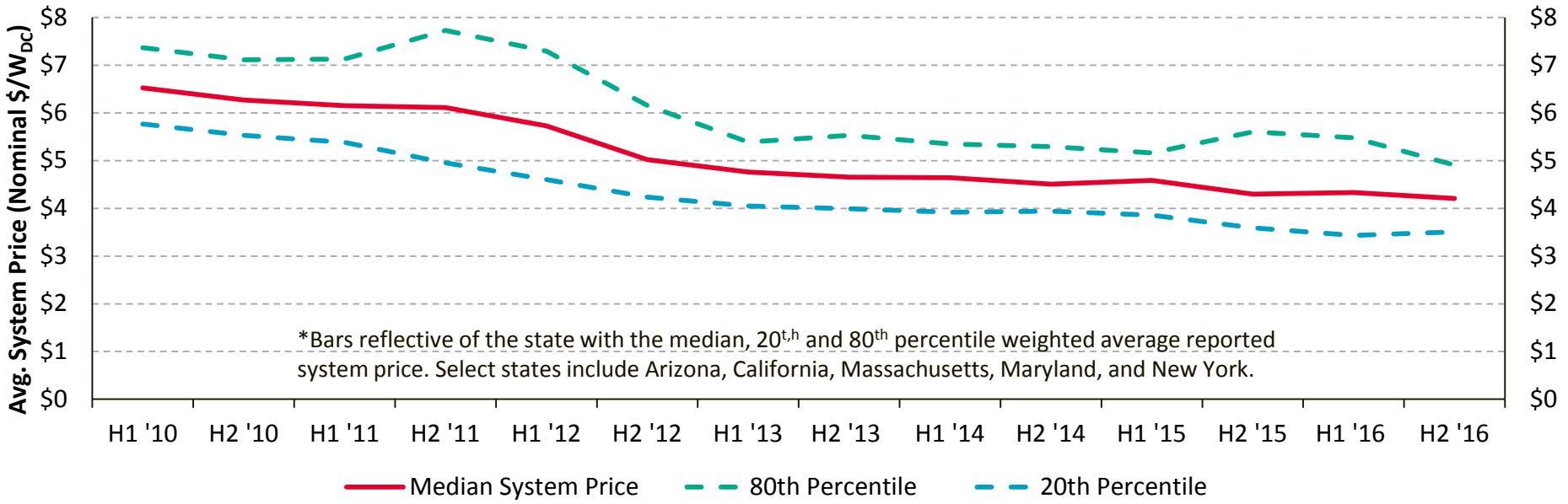
# System Pricing from Select States

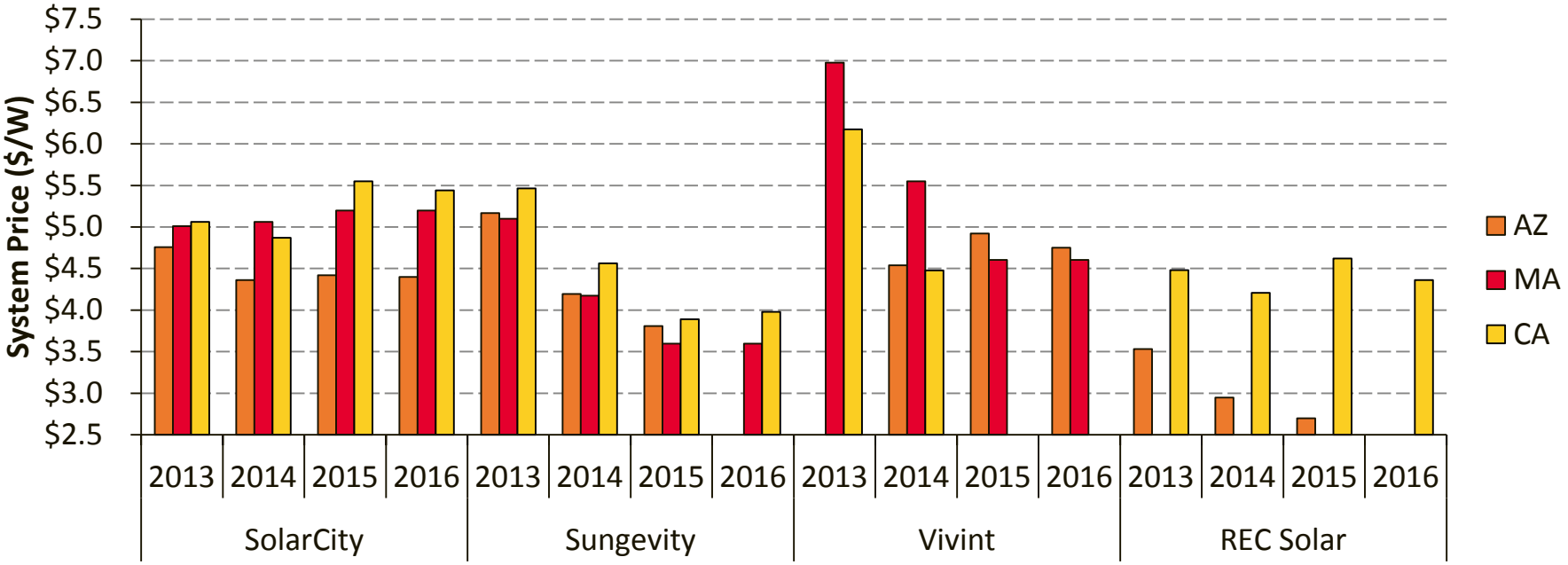
## 2.5 kW–10 kW




- In 2016, the median reported system price was flat, but the price range contracted.
- System prices fell, on average, 2% between H1 2016 and H2 2016.
- Lowest prices (20th percentile) were seen in Arizona ($2.97/W), while higher prices (80th percentile) were seen in California ($5.63/W) in H2 2016.

2016 MW: AZ (72); CA (197); MA HO (69); MA 3-P (33); MD (0.1); NY H.O (43); NY 3rd-P (72).
**Note**: MA does not report whether a system is third-party owned. Therefore, it was estimated using the "applicant entity" or "installer" for the following organizations: SolarCity, CPF Capital, Sunrun, Vivint, and Sungevity.
**Sources**: CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; MD Energy Administration; NY PV Incentive Program. All programs accessed 12/14/16.

# System Pricing (<10 kW) by Company in Different States

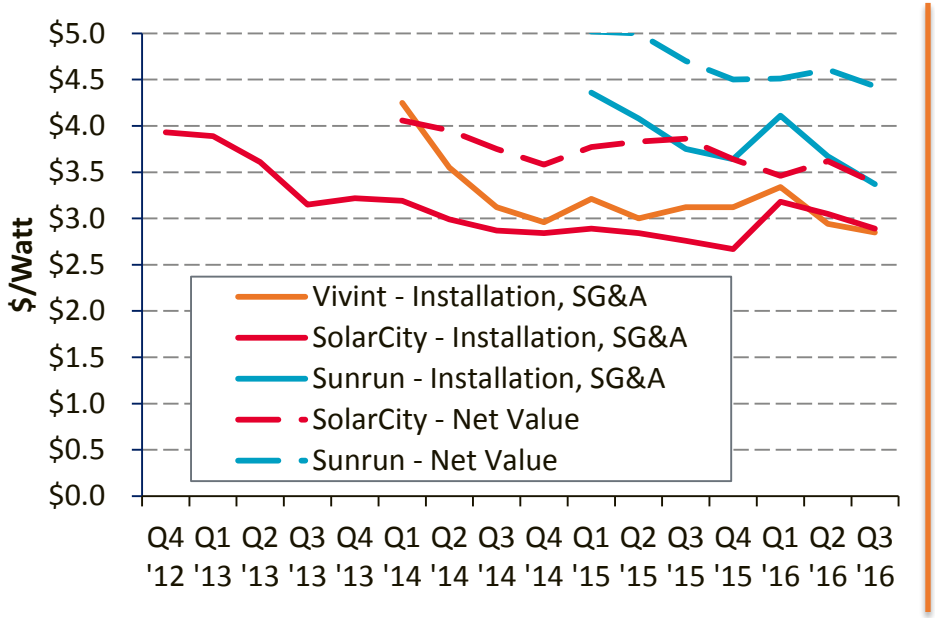


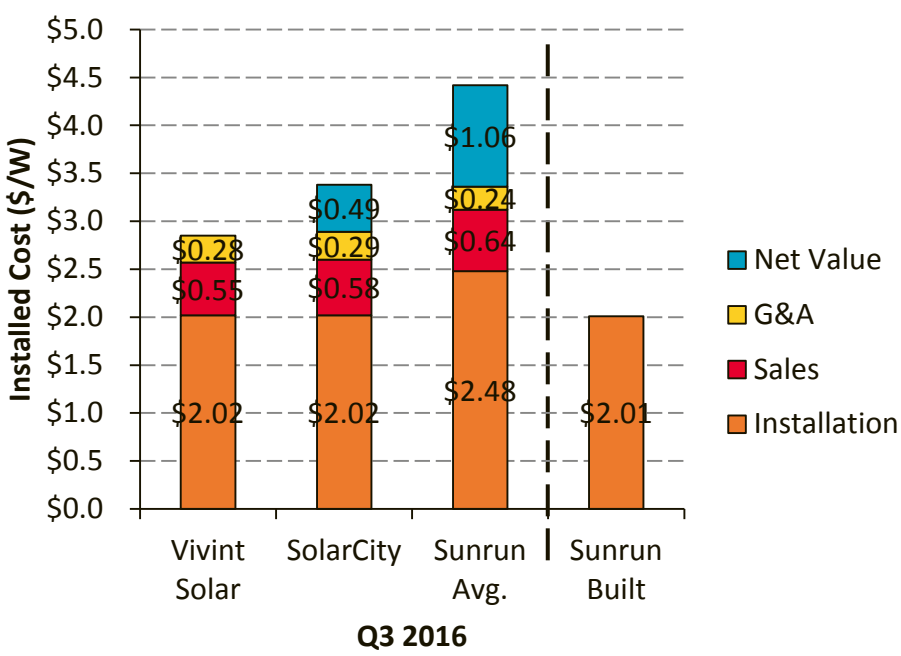

- The same company can report pricing with a delta of $0.5/W–$1/W between states.
- The difference in reported price can vary even greater within the same state between installers.
- System price trends over time also vary greatly, with some even increasing over time.
- These reported differences could be caused by many factors including: regional cost variation, the use of value-based pricing, changing incentives, financing, local regulations, system design, and what companies include in reported system price.

2016 MW installed:
AZ: SolarCity (30); Vivint (5.4); Sungevity (0.122)
CA: SolarCity (20.4); Sungevity (6.7); REC Solar (5.9)
MA: SolarCity (33); Vivint (20); Sungevity (3)

**Sources**: CA NEM Database, accessed 12/14/16; MA SREC Program, accessed 12/14/16; Arizona Public Services and Salt River Project, accessed 12/14/16.

# SolarCity, Vivint Solar, and Sunrun Cost and Value



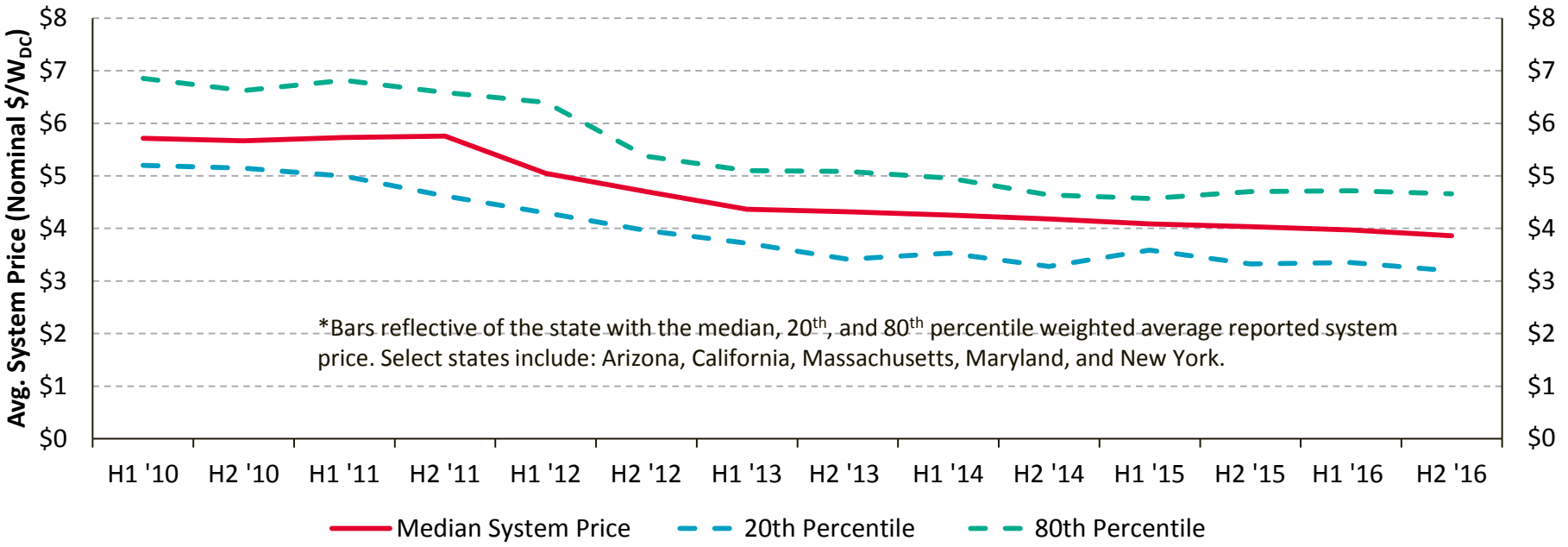




- In Q3 2016, SolarCity, Sunrun, and Vivint Solar costs dropped Q/Q, though SolarCity costs are still above Q4 2015-reported costs.
  - Costs are higher than expected due to lower-than-expected deployment (and thus, fewer MW in which to spread fixed costs).
  - However, all three companies reported integrator-built system pricing below $3/W in Q3 2016.
- Developers report value for projects to be between $3.3/W and $4.5/W.

**Sources**: Corporate filings

# System Pricing from Select States

## 10 kW–100 kW




- Reported host-owned system prices for systems 10 kW–100 kW fell 2% between H1 and H2 2016.
  - Third-party systems also fell by 2% during that timeframe.
  - Third-party systems are being *reported*, on average, $1/W–$2/W more expensive than host-owned systems. Third-party owners may use different methodologies to determine a price.
- Lowest prices (20th percentile) were seen in Arizona ($2.84/W), while highest (80th percentile) were seen in New York ($5.04/W) for third-party-owned systems.

2016 MW: AZ (48); CA (61); MA HO (38); MA 3-P (16); MD (0.14); NY H.O (44); NY 3rd-P (39).

**Note**: MA does not report whether a system is third-party owned. Therefore, it was estimated using the "applicant entity" or "installer" for the following organizations: SolarCity, CPF Capital, Sunrun, Vivint, and Sungevity.

**Sources**: CA NEM database; MA SREC Program; Arizona Public Services and Salt River Project; MD Energy Administration; NY PV Incentive Program. All programs accessed 12/14/16.

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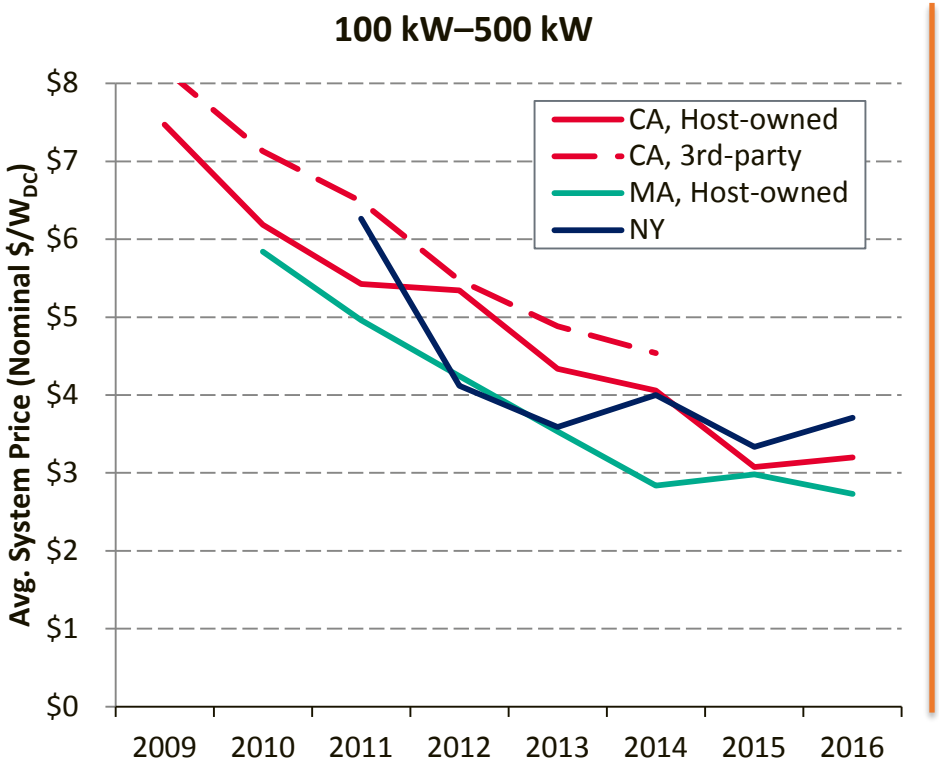
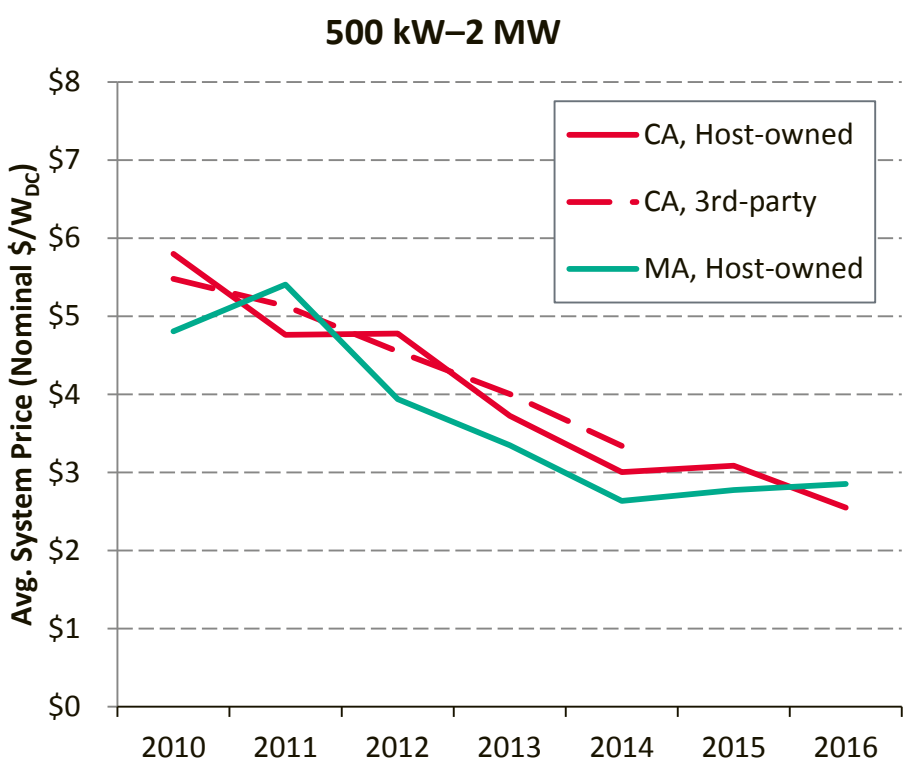
# Average System Pricing by Size and State

## 100 kW–500 kW and 500 kW–2 MW




- Average reported system prices for large systems in the above states remained relatively flat in 2015–2016, with considerable variation among individual states.

2016 MW: (100–500 kW): CA H.O. (53); MA H.O.(22); NY (47). (500 kW–2 MW): CA H.O. (45); MA H.O.(50).

**Sources**: CA NEM database; MA SREC program; NY PV incentive program. All programs accessed 12/14/16.

# Utility-Scale PV Pricing Trends

- Utility-scale PV system price reductions continue in 2016, with most reports well below $2/W.
- GTM Research and SEIA report that the Q3 2016 capacity-weighted average utility-scale PV system price was $1.21/W—down 21% y/y.
- BNEF expects the global benchmark for ground-mounted PV systems above 1 MW to be $1.14/W in 2016—down 13% y/y.
- SolSystems reported in December 2016 that a developer all-in asking price for PV systems for >2 MW was $1.8/W—down 20% y/y.
- In October 2016, it was announced that Florida Power & Light is allowed to rate-base the development of 300 MW of PV from 2017 to 2020, subject to a cost cap of $1.75/W-AC ($1.35/W-DC, assuming a 1.3 inverter loading ratio).
- UBS reports an implied utility-scale PV system price for First Solar of $1.23/W and a build cost of $0.93/W.



**Sources**: GTM Research & SEIA, "U.S. Solar Market Insight: Q3 2016" (December 2016); BNEF, "Q4 2016 Global PV Market Outlook" (11/30/16); SolSystems (December 2015; December 2016); UBS (11/18/16)

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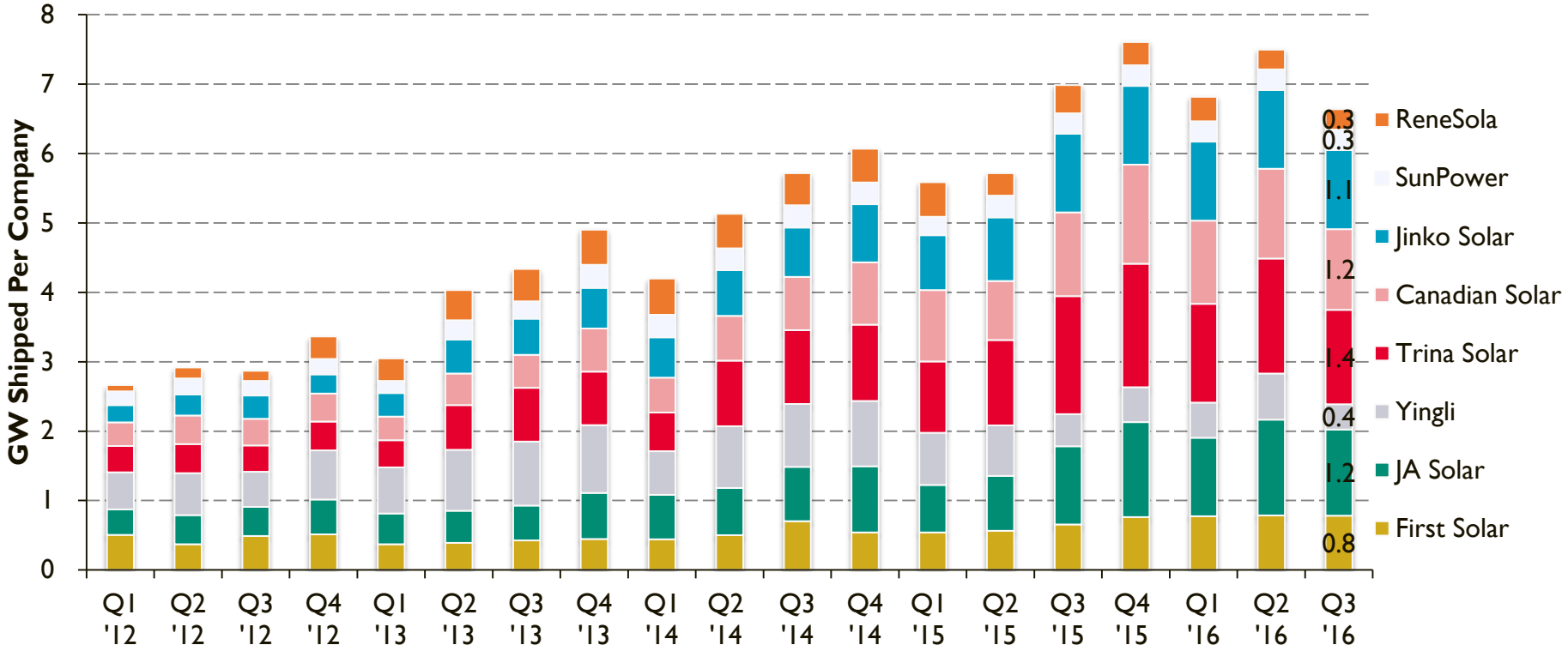
# Manufacturers' Shipments

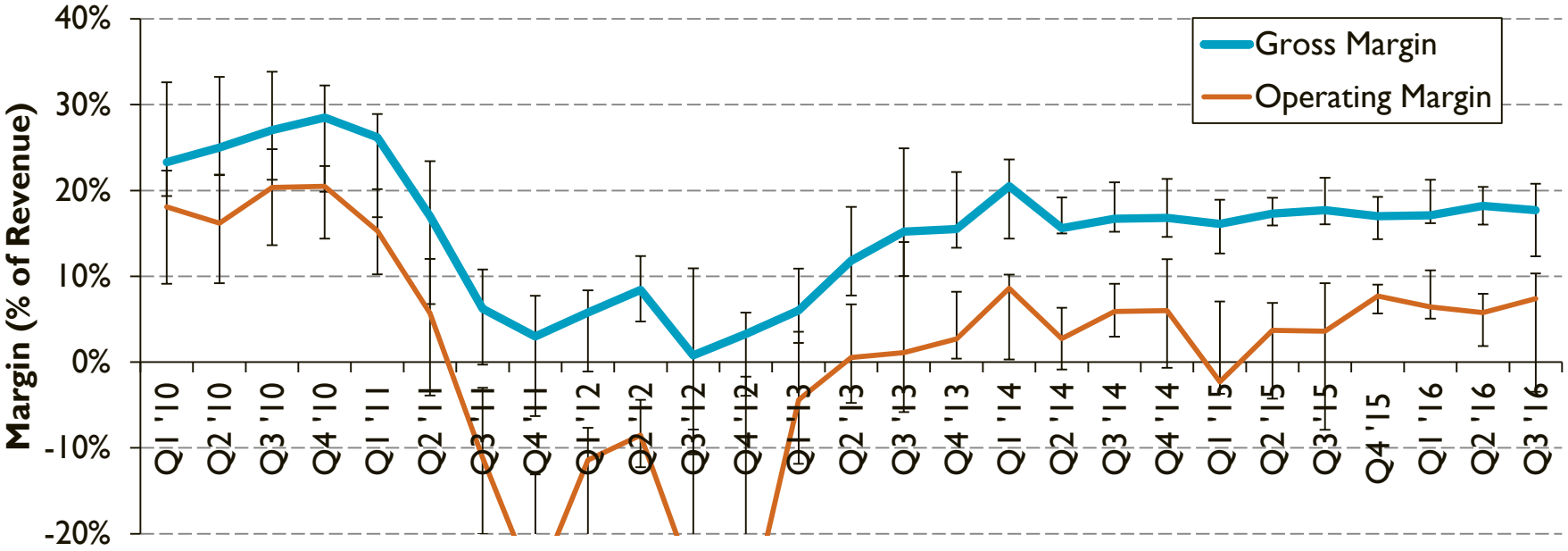
## Top Cell/Module Manufacturers




- In Q3 2016, the above companies shipped 6.8 GW.
  - The Q3 2016 total is 11% less than Q2 2016 and 5% less than Q3 2015.
  - Trina leads in shipments with 1,361 MW shipped; JA Solar follows with 1,241 MW shipped.
- Fewer firms may be publicly reporting shipments in the future.
  - Hanwha Q Cells have announced that they will cease reporting shipments for competitiveness reasons.
  - Trina Solar is planning on going private in Q1 2017 and thus would not report shipments through regulatory filings.

**Note:** First Solar reports production, not shipments.
**Sources**: Company figures based on Q3 2016 (and previous) SEC filings by the respective companies.

# PV Manufacturers' Margins




**Line represents the median, with error bars representing 80th and 20th percentiles for the following companies: Canadian Solar, First Solar, Hanwha Q Cells, JA Solar, Jinko Solar, ReneSola, SunPower, Trina Solar, and Yingli Solar.*

- Industry margins were flat Q2–Q3 2016, with some variation among individual companies.
  - There were 18% median gross margins and 7% median operating margins of the above companies in Q3 2016.
- First Solar has maintained the strongest gross margins in the industry (27%); Yingli had the weakest gross margin of the surveyed companies at 6% in Q3 2016.
  - Most Asian manufacturers saw gross margins of 17%–20% in Q2 2016.
- Some manufacturers saw large (~10%) drops in margin Q2–Q3 2016, likely brought on by a drop in module pricing.
  - However, because there was not a dramatic drop in margins for most companies, the lower-priced modules may be shipped in subsequent quarters (or costs may fall in lock-step).

**Sources**: Company figures based on Q3 2016 (and previous) SEC filings by the respective companies .

# Changes in U.S. Solar Manufacturing

- Suniva's $100MM expansion of its cell factory in Georgia was completed in late 2016 (with help of Shunfeng's recent investment). This will triple its capacity to 430 MW. Suniva plans to expand again to 700 MW by mid-2017.
- In H1 2016, SolarWorld finished its 150-MW capacity expansion of manufacturing in Oregon (now totally 550 MW)—it now employs 900 people in that location (up from 600).
- In November 2016, First Solar announced it would cut 450 jobs in Ohio as it transitions to manufacturing a more advanced module (Series 6).
  - The company said that it will continue to "lead the way in new technology development" in Ohio—it is unclear whether the employees will be hired back when the new module begins production in 2018.
- Kerfless wafer manufacturer 1366 Technologies is set to break ground in 2017 on a 250-MW plant in upstate New York, which is scheduled to come online by the end of the year.
  - In mid-2016, the company signed an agreement to supply Hanwha with 700 MW of wafers, followed by an agreement with Wacker, which will provide the polysilicon for the wafers and a $15MM investment to help with construction of the plant.
- ABB and SMA both announced plans in Q3 2016 to close inverter production in the United States and consolidate manufacturing in their European plants—due to this transition, U.S. inverter manufacturing fell 18% in Q3 2016.



**Sources**: GTM Research & SEIA "U.S. Solar Market Insight: Q4 2016" (December 2016); The Portland Business Journal (05/06/16); RECharge (10/06/16); The Toledo Blade (11/18/16)

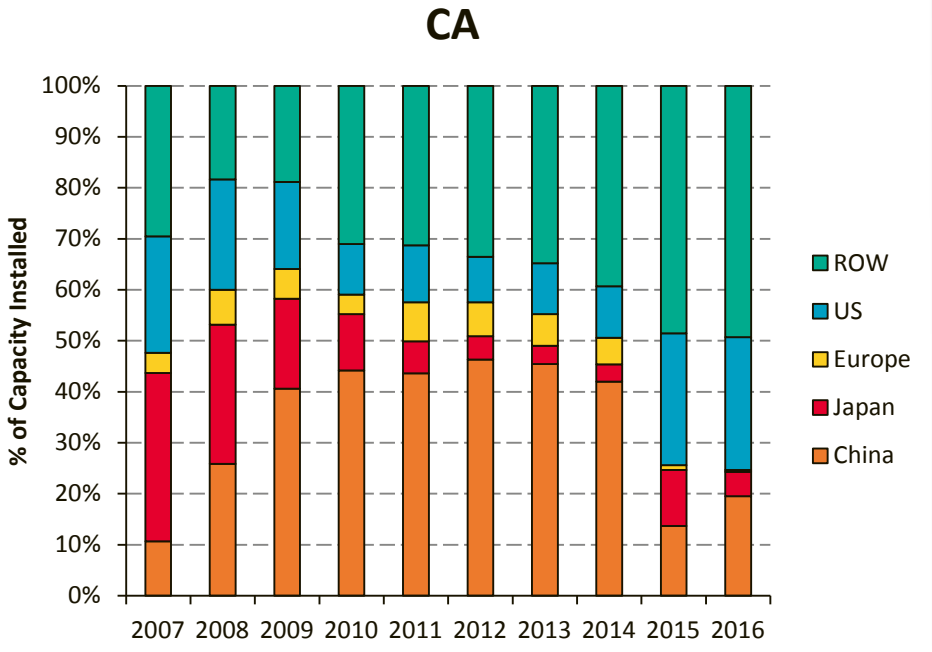
# Changes in U.S. Solar Manufacturing (cont.)

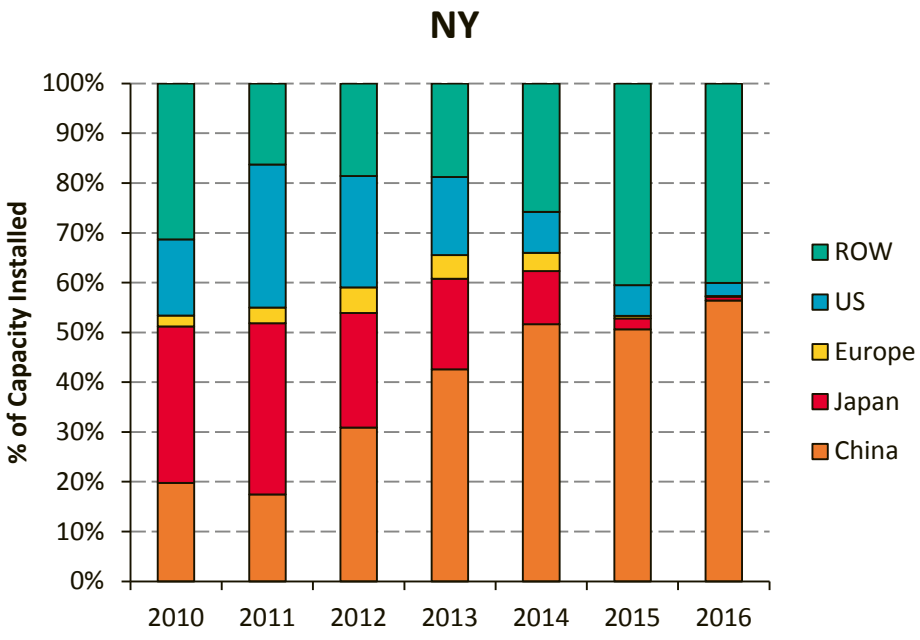
- Tesla and Panasonic finalized plans in December 2016 to collaborate to make solar cells and modules.
  - Panasonic, is investing more than $256MM in the Buffalo, NY manufacturing plant, and is responsible for PV cell production.
  - Tesla will assemble the cells into a module or a shingle.
- Tesla and Panasonic also plan to combine their PV cell technologies to drive costs down to $0.4/W; however, as they use different size wafers, it may take time to create the new product.
- The joint manufacturing plant in Buffalo, New York, is scheduled to begin production by the summer of 2017, and ramp-up to 1 GW by 2019.
  - When SolarCity purchased Silevo in 2014 it had planned to achieve a 1 GW manufacturing capacity by 2016 or 2017.
- In November 2016, Tesla/SolarCity announced that it had started the hiring process in Buffalo, New York.
  - Tesla/SolarCity held “workforce information sessions” with plans to hire 1,460 workers, 500 of which are in manufacturing.
- Tesla and Panasonic are also building a $5B lithium-ion battery factory in Nevada, which is on schedule to support the H2 2017 rollout of Tesla’s Model 3 car (the companies also plan to follow up with another battery gigafactory in Europe).



**Sources**: Bloomberg (10/17/16, 10/31/16, 12/28/16); The Buffalo News (11/21/16); Cowen & Co (11/02/16); Greentech Media (12/07/16); PV Magazine (10/26/16)

# Regional Mix of Modules Installed in CA/NY



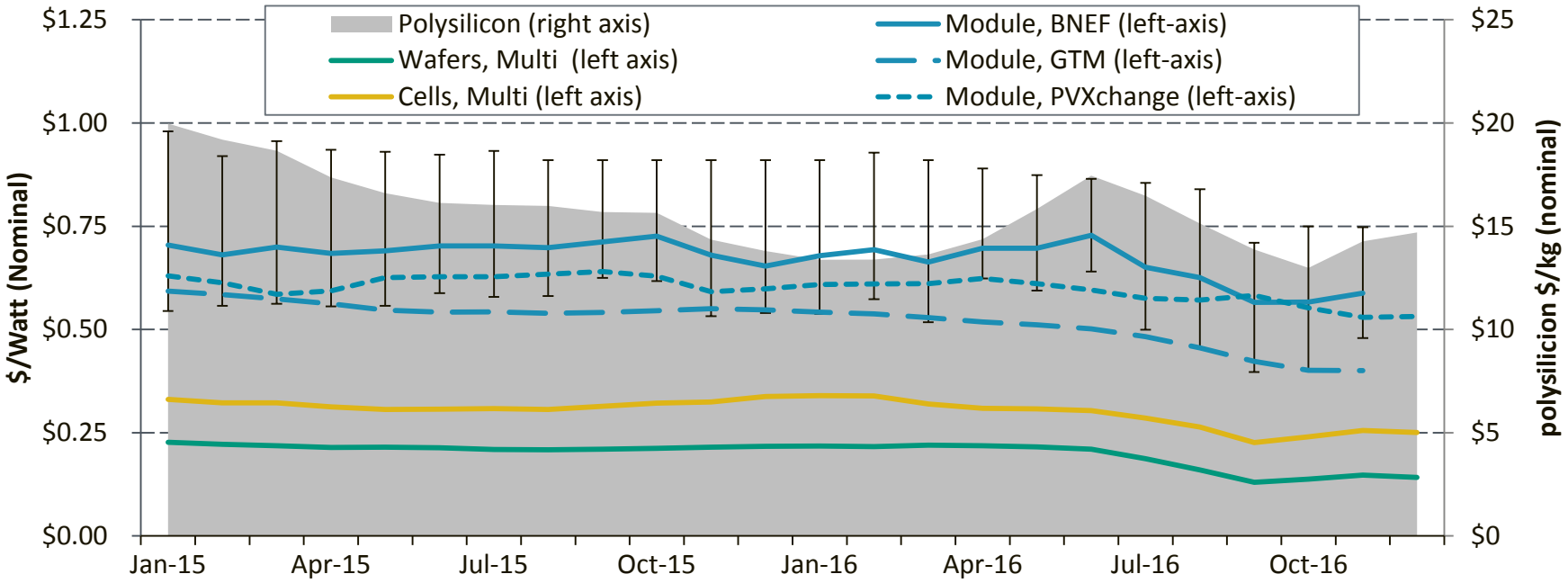

- The share of Chinese modules in the CA NEM database has begun to decrease in favor of the rest of the world (ROW) and U.S. modules.
  - SolarWorld, with manufacturing based in Washington state, accounted for 98% of U.S. manufactured modules in the CA NEM database for 2016.
  - In 2012 and 2014 the U.S. began imposing tariffs on Chinese-made solar products.
- In New York, ROW- and Chinese-manufactured panels account for 96% of installations.

**Note**: Module manufacturers were designated a country based on the majority of their manufacturing facilities. Ex: SunPower, headquartered in the United States, was grouped with ROW.
**Sources**: CA NEM Currently Interconnected Data Set; NY PV Incentive Program, accessed 12/14/16

# Agenda

- U.S. Deployment
- U.S. Pricing
- Global Manufacturing
- Component Pricing
- Market Activity
- Off-Grid Solar

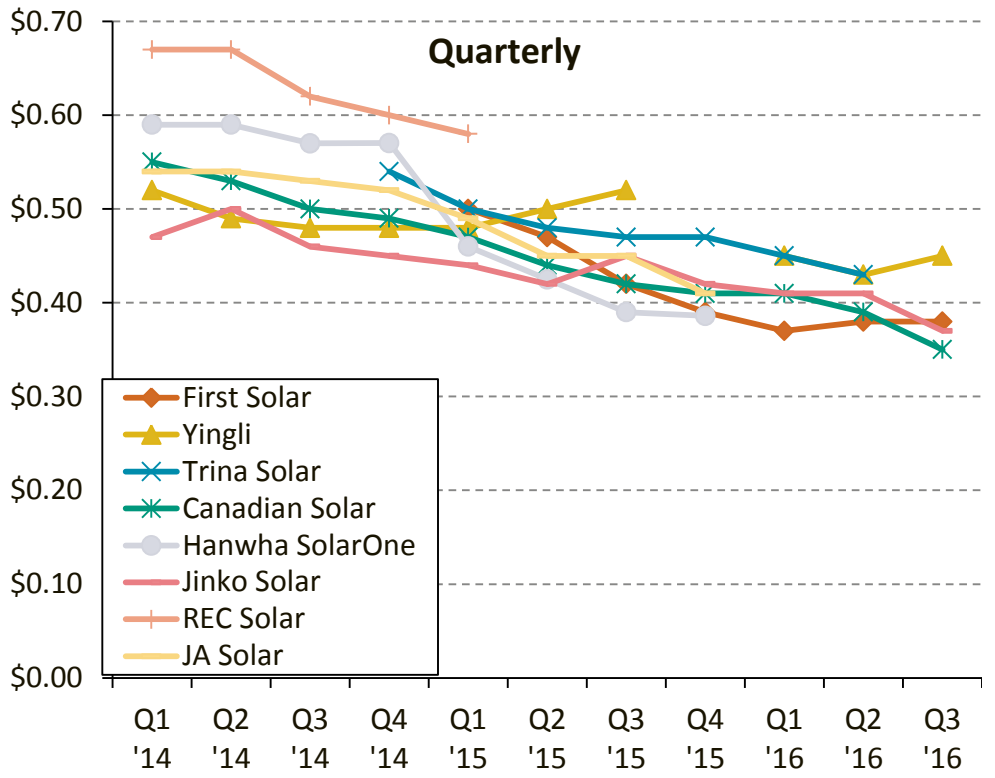
# Module, Cell, Wafer, and Polysilicon Price

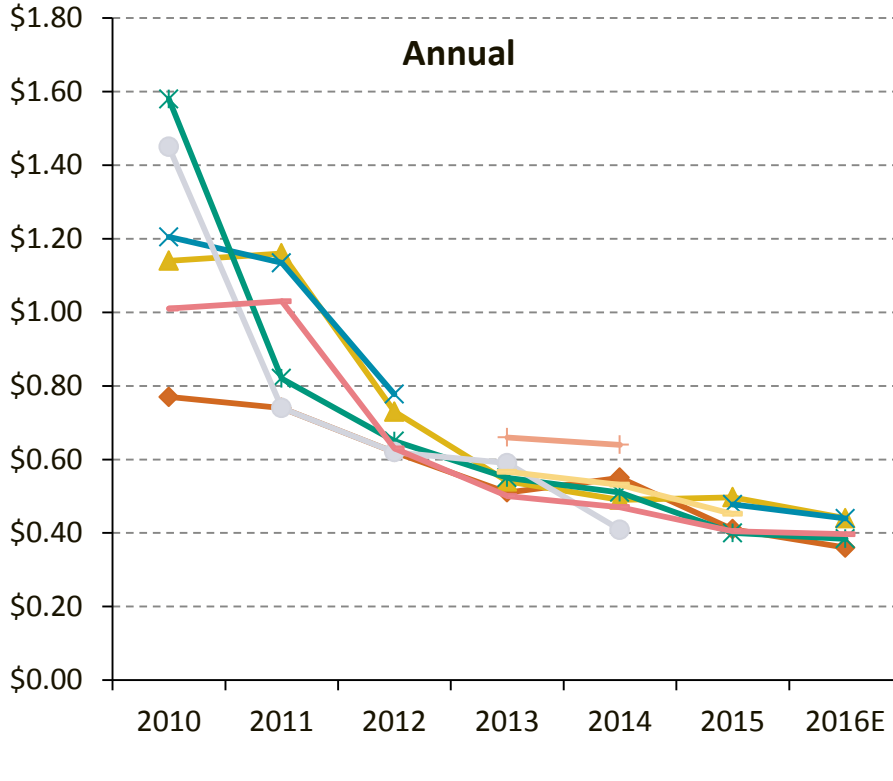



- After several years of relatively flat pricing, module and components have begun a period of rapid price declines.
- Despite the general consensus of a lower-priced environment, there are a range of reported market prices, due in part to geographic differences and the differences in delivered prices versus booked prices.
  - BNEF reports an increase in pricing in Q4 2016 due to a rush in orders.

**Note**: Error bars represent high and low quotes.
**Sources**: BNEF Solar Spot Price Index (12/16/16); GTM Research, PV Pulse (November 2016); PVXchange (12/16/16).

# PV Manufacturers' Costs




- In Q3 2016, module costs were between $0.35/W and $0.45/W.
  - Q3 2016 costs from the above companies are down $0.02 compared to Q2 2016, with significant variation among individual companies.
- Costs of currently reporting companies have decreased by 13% since Q3 2015.
- Manufacturers report in-house costs $0.02–$0.05 less than blended costs.

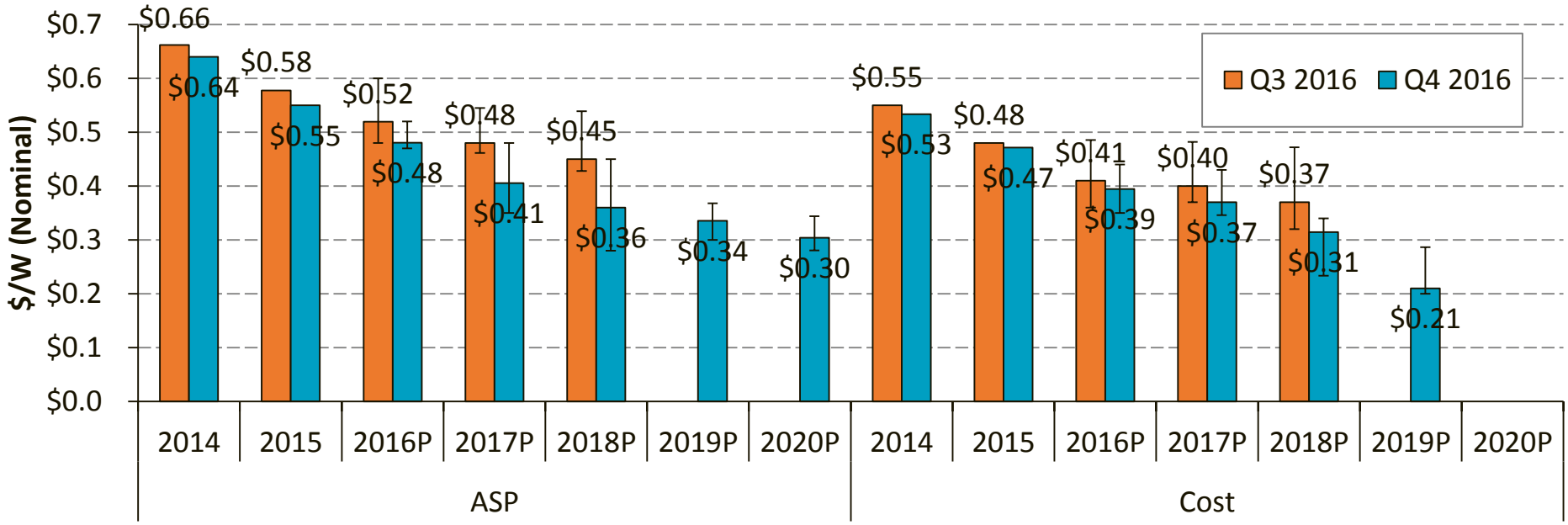
**Sources**: Company figures based on Q3 2016 (and previous) SEC filings by the respective companies (Deutsche Bank 8/01/16, 8/23/16, 8/25/16).

# Roadmap Acceleration by Module Manufacturers

- Module manufacturers are accelerating their technology roadmaps to compete in the new low-priced module environment.
- In November, First Solar announced that it would move its Series 6 module timeline ahead by a year, essentially skipping Series 5. The results in 2018 are projected to be:
  - 18% module efficiency to start—19% over time
  - 40% lower costs than Series 4, translating to an estimated cost of $0.20/W–$0.25/W
  - 25% lower capital expenditures (~$0.3/W)—though ~$300MM–$400MM in ramping costs
  - 50% lower labor costs due to higher throughput.
- Canadian Solar announced in September that it expects to have an internal manufacturing cost of $0.29/W by Q4 2017 and $0.25/W by Q4 2020—down from $0.35/W in Q3 2016.
  - Its cell efficiency roadmap targets a multi-cell efficiency of 19% by Q4 2018—up from approximately 18.5% now.
  - Cost reductions will be pursued through lower polysilicon costs, higher throughput, and a reduction in raw material use.
- SunPower announced a $250MM restructuring initiative to lower costs.
  - It will reduce its workforce by 25% and bring 700 MW of older technologies offline.
  - SunPower also plans to increase production of its newer, high efficiency P-series and X-series panels. The interdigitated back contact X-series cells achieved a median cell efficiency of 24.7% in Q3 2016 (~23% panel efficiency).

**Sources**: Cowen & Co (11/17/16, 12/07/16); Deutsche Bank (11/16/16, 11/18/16); Goldman Sachs (11/16/16); UBS (11/18/16)

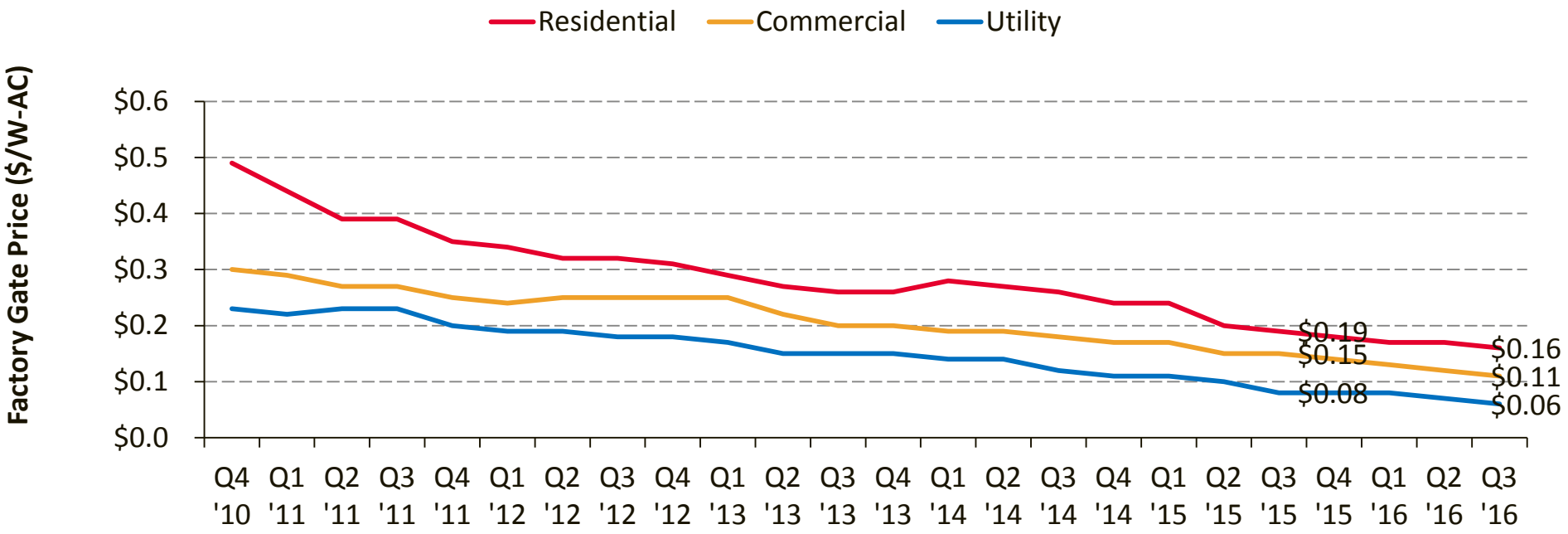
# Near-Term Module Price/Cost Projections




- Analyst projections made in Q4 2016 indicate module prices and costs are expected to drop significantly in the next few years, with some analysts expecting prices around $0.3/W and costs around $0.2/W by 2020.
- These projections are significantly lower than those made in Q3 2016.
  - The Q4 2016 median ASP and cost projections for 2018 are 22% and 15%, respectively, below Q3 2016 projections.

**Sources**: Lines represent the median estimates, and error bars represent the maximum and minimum ASP and costs for First Solar, Yingli, and industry averages from the following analysts: BNEF (09/01/16, 11/30/16); Cowen (08/10/16, 11/03/16); Deutsche Bank (08/03/16, 08/23/16, 11/16/16, 12/08/16); GTM Research (July 2016, November 2016); IHS Research (06/20/16, 10/06/16).

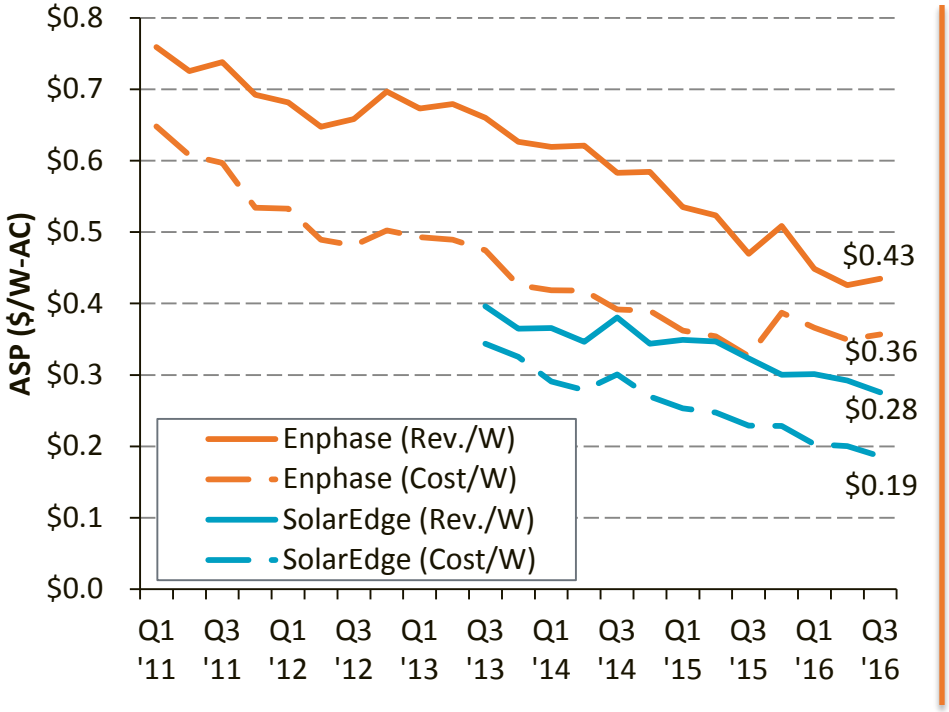
# Inverter Pricing

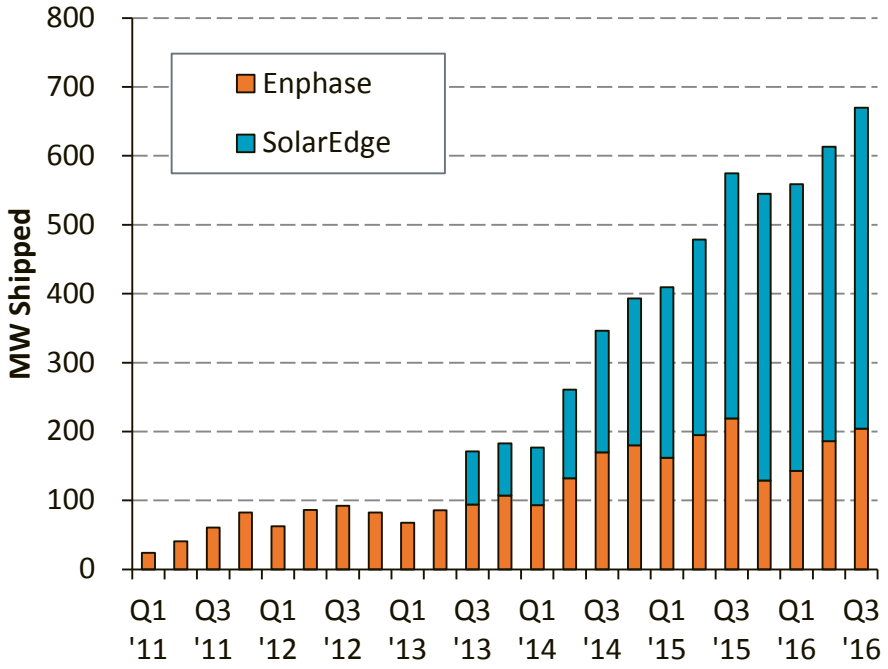



- From Q3 2015 to Q3 2016, inverter prices in the United States dropped by about one quarter.
  - In Q3 2016, utility-scale inverter ASP was about half of the original SunShot target for 2020 of $0.1/W
  - Falling inverter prices are partly due to pressure from Chinese inverter manufacturers and newer products in the marketplace (e.g. 1,500-volt inverters, residential optimizer/inverter solutions).
- Since Q4 2010, inverter prices have fallen by 60%–75%.

**Source:** GTM/SEIA "Solar Market Insight Q4 2016"

# Enphase Microinverters and SolarEdge DC-Optimized Inverter Systems




- From Q3 2015 to Q3 2016, Enphase inverter and SolarEdge optimizer prices fell approximately 7% and 15%, respectively; however, SolarEdge costs decreased 19% while Enphase costs increased 9%.
  - Enphase has cut its price to try to regain market share while it pursues an aggressive cost reduction roadmap with a target cost of $0.10/W by the end of 2017.
- SolarEdge shipments grew 48% in the first 9 months of 2016 compared to the same period in 2015, while Enphase shipments dropped 7% over the same period.

**Sources**: Enphase/SolarEdge public filings

# Agenda

- U.S. Deployment
- U.S. Pricing
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# State-Level Policy Update

- **Nevada** – A ballot initiative was approved on Election Day to break up the state's monopoly utility, NV Energy. The Nevada PUC also voted to restore net metering for existing solar customers on September 16.
- **Arizona** - The AZ Corporation Commission staff voted 4–1 to eliminate NEM for future solar customers. Compensation for new customers will be decided in a new rate case, while existing customers will be grandfathered for 20 years. An AZ administrative judge has recommended that AZ compensate solar customers based on an avoided cost mechanism, with a 5-year forward forecast.
- **Utah** – Utah's largest municipal utility (Provo Power) approved fees of $3/kW per month for all net-metering customers. Existing customers will be given a credit for up to 2 kW of installed solar. The mayor of Provo announced that he would veto the fee. Rocky Mountain Power (RMP), the state's largest utility, issued a similar proposal for solar customers that would have added demand charges, a $15 fixed charge and an additional $0.03/kWh charge. The Utah PSC has suspended RMP's request.
- **Illinois** – The state passed a bipartisan bill designed to restructure the state's electricity sector. The bill authorizes $235M in payments for the state's uneconomic nuclear plants and increases the public investment in renewable energy and energy efficiency. Most notably, utilities will have to reduce demand by 16%–21.5% (depending on the utility) and authorize $360M for low-income solar programs and $100M for RPS compliance costs. The bill also authorizes new community solar programs and upholds net metering. It is expected to spur 3 GW of PV deployment by 2030.

**Sources**: Greentech Media (11/9/16; 9/16/16), Utility Dive (10/11/16; 12/12/16; 12/13/16; 12/15/16; 12/16/16)

# State-Level Policy Update (cont.)

- **Florida –** A utility-backed ballot initiative was rejected by voters on Election Day. The initiative would have amended the state constitution to allow homeowners to purchase or lease solar, while outlawing cross-subsidies for solar energy. The amendment was widely perceived to be an attempt to undermine net metering in the state. Amendment 4, which authorizes the legislature to consider exempting C&I solar from property taxes, was approved.
- **Michigan –** State legislatures passed a bipartisan energy reform bill that expanded the state's RPS to 15%, preserved retail net metering, and expanded utility efficiency goals. The bill also outlines a process for creating a new tariff for distribution solar generation.
- **Hawaii –** Regulators denied an appeal to raise the state's "grid supply" cap. Going forward, distributed solar systems will be required to "self-consume," receiving no compensation for exported electricity.



**Sources**: Greentech Media (11/9/16; 9/16/16), Utility Dive (10/11/16; 12/12/16; 12/13/16; 12/15/16 12/16/16)

# Tesla-SolarCity Merger is Finalized; Company Launches New Roof Product

- Shareholders at Tesla approved a $2.6B all stock purchase of SolarCity.
- The merger was approved by 85% of Tesla shareholders.
  - CEO Elon Musk and other shareholders with conflicts of interest recused themselves from the vote.
- External reception of the deal varied with some analysts advising shareholders to approve the purchase as Tesla is acquiring SolarCity with little to no premium, while others equated it to a bailout.
- Musk has historically utilized unusual financial transactions to support his three companies .
  - SpaceX, another of Musk's companies, is the largest owner of SolarCity's solar bonds, including 85% of SolarCity's latest bond offering.
  - Musk has also supported his companies with $475MM of personal loans secured by $2.51B of Musk's personal stock.
- Tesla announced a new solar roof product to demonstrate the benefits of the merger.
  - Tesla has not issued firm cost or technology specifications but released pictures of the product and indicated that it will have "a quasi-infinite lifetime" and will cost less than a traditional roof plus electricity from the grid.
  - Most analysts have indicated that the roof will be a premium product and noted that the slate and terracotta materials the solar roof mimics are among the most expensive roofing products.
  - Many companies have struggled to commercialize solar shingles—most notably DOW who stopped production of their CIGS shingles this past summer.

SunShot U.S. Department of Energy

energy.gov/sunshot



**Sources:** WSJ (11/17/16, 4/27/16); Bloomberg (10/31/16); GTM (7/1/16) ; Photo credit: Tesla: https://www.tesla.com/solar

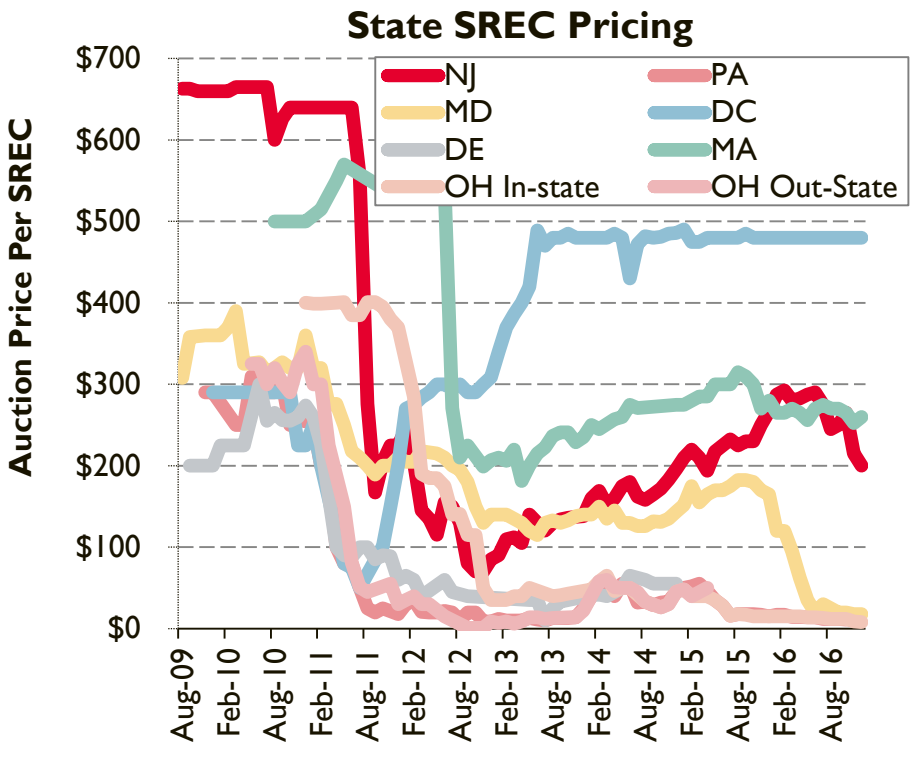
# SolarReserve Announces Intention to Build 2-GW Solar Plant

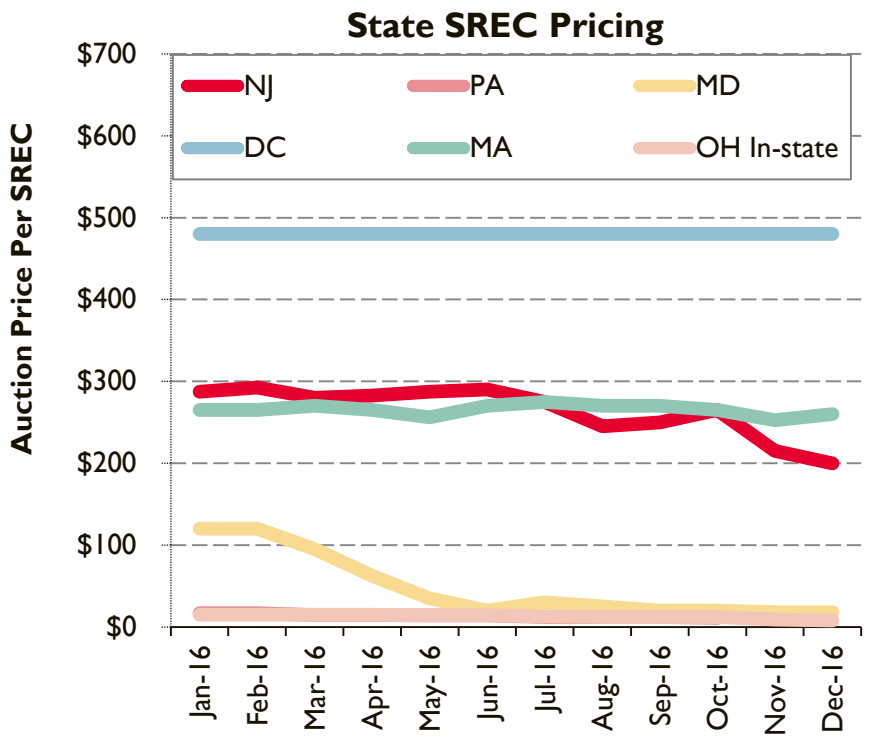
- In October, SolarReserve announced its intention to build a $5B, 2-GW molten salt power tower, with energy storage in Nye County, Nevada.
  - As planned, the project would have 10 towers and cover 15,000 acres.
  - The company has identified two potential sites, both of which would require an expansion of transmission capacity.
- SolarReserve has claimed that scale is its primary strategy for cost reduction and believes that a project at this scale can deliver power at a lower cost than a natural gas plant.
  - SolarReserve's other project, Crescent Dunes, sells power to NV Energy under a 25-year PPA for $0.135/kWh.
  - Analysts currently peg CSP costs as $119/MWh–$181/MWh, while combined cycle gas plants can produce at $52/MWh–$78/MWh.
  - Gas peaking plants (at $165/MWh–$218/MWh) are more closely aligned with the current cost of CSP.
- SolarReserve has presented this project to a number of California utilities as an alternative to battery storage
- Analysts have expressed skepticism about the project because SolarReserve has not identified an exact site, secured financing, or found a buyer for the power.



**Sources**: Bloomberg 10/13/16, Utility Dive 10/17/16

# SREC Markets



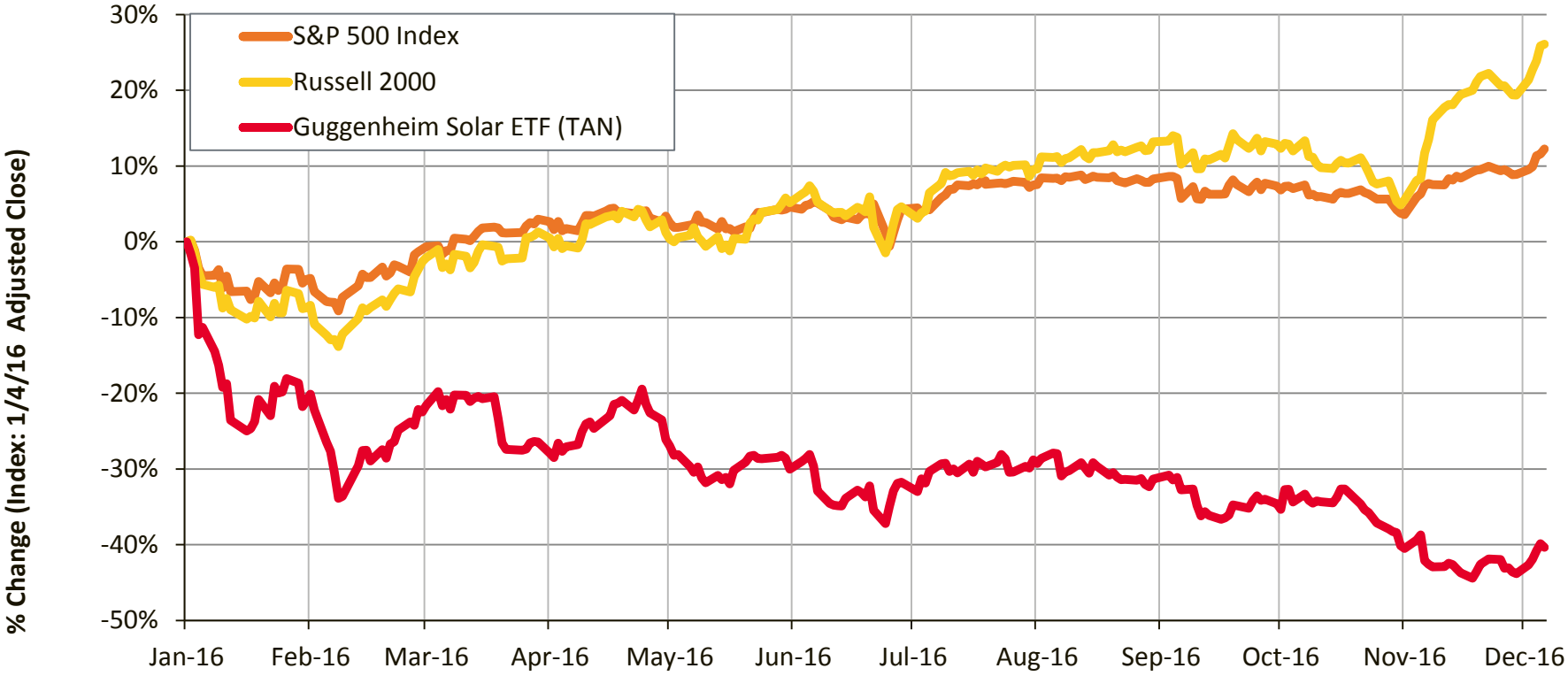




- SREC prices have generally declined or been flat in 2016 but without much of the volatility that has characterized previous years.
- Maryland SREC continues to be depressed due to SREC oversupply, as installations have outpaced RPS requirements.
- New Jersey's SREC market has seen volatility due to upward revisions of reported capacities, which could indicate an oversupply in future years.

**Sources**: Blog, SRECTrade, www.srectrade.com (accessed 12/12/16)

# Market Activity

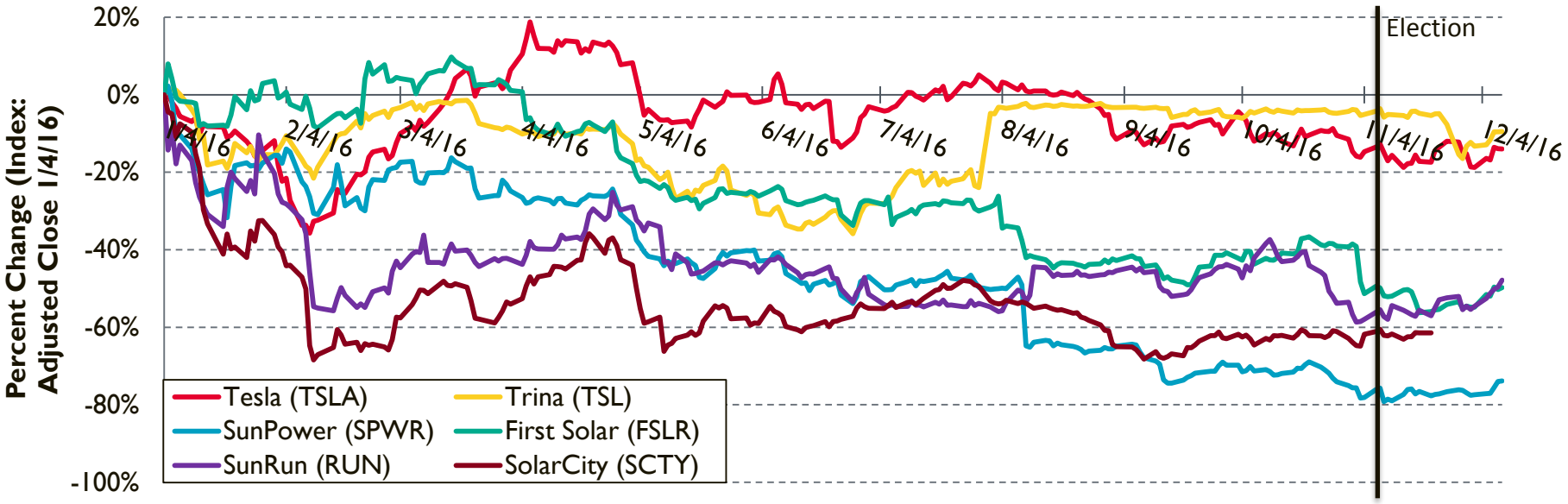
- Solar stocks continue to underperform relative to the general stock market.
- TAN saw a drop in Q3 2016 (↓8.8%) and is ↓40% YTD.
  - S&P 500 is ↑4.5% in Q3; Russell 2000 is ↑12%.
- Missed deployment projections and weaker-than-expected growth in the distributed market impacted solar stock prices in 2016.






**Note:** Average market capitalization of securities in TAN was $154 million (09/30/16); Russell 2000, $1.7b (05/27/16).
**Source:** Stock Market: Yahoo Finance (12/9/16)

# 2016 Stock Performance of Solar Companies




- The effect of the election on solar stocks was relatively small compared to losses that occurred throughout the year.
  - Some solar stocks lost 5%-15% of their value; however, most of them have since recovered.
  - Many of these solar stocks had lost more value during 2016 prior to the election due to macroeconomic factors.
- The extension of the ITC has led some buyers to delay procurement of renewable energy, and as a result, many companies have missed deployment projections which has impacted stock prices.
- Influx of low-priced modules into the market has led to turbulence in stock prices. Many module manufacturers, including First Solar and SunPower, have announced restructuring plans in response.

SunShot U.S. Department of Energy

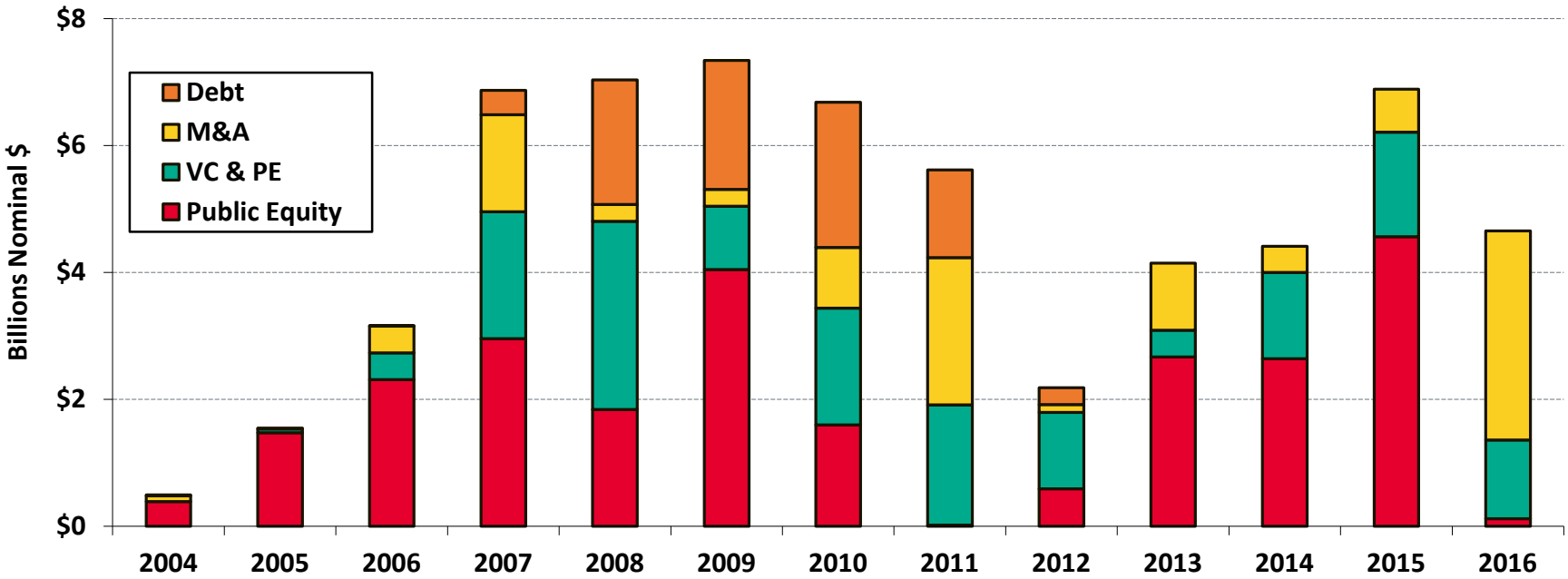


energy.gov/sunshot

**Sources**: Stock information: Yahoo Finance (updated 12/12/16); corporate press releases

# Solar Corporate Investment Activity, United States

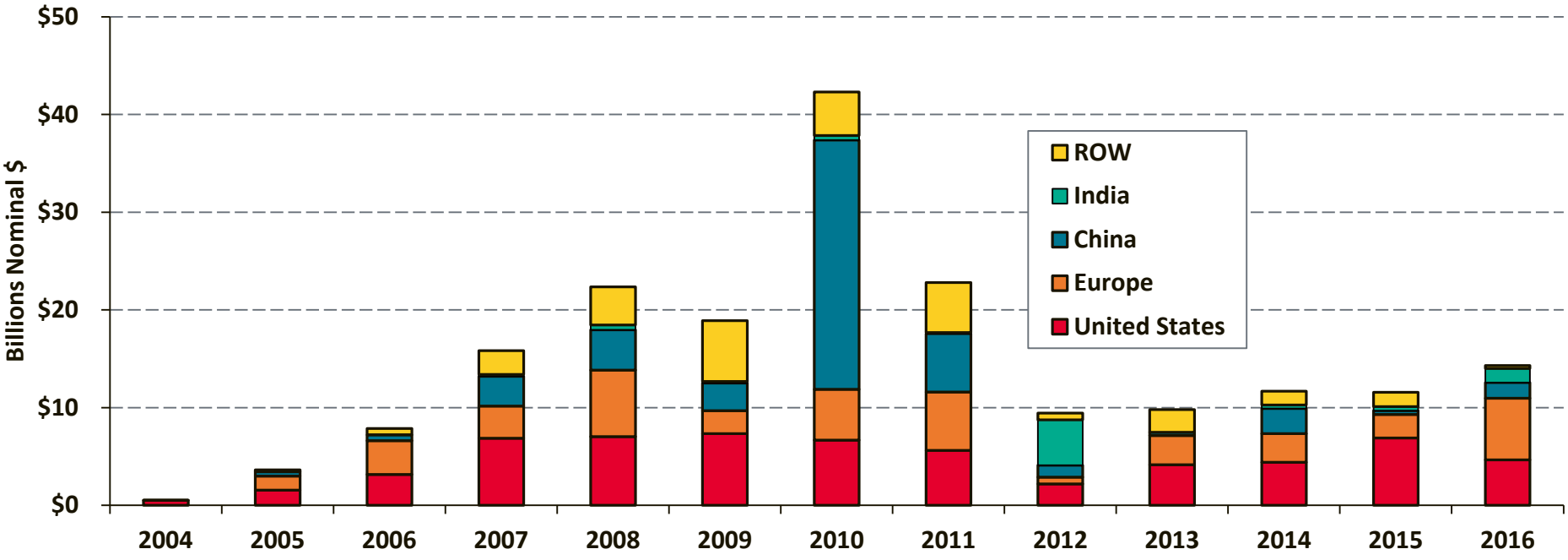
- U.S. corporate solar investments in 2016 were on par with 2015 with ~$4.7B.
  - 56% of the investments came from one transaction—the $2.6B acquisition of SolarCity by Tesla.
- Solar public capital raises were at their lowest levels since 2011.




**Notes**: Excludes PG&E $300MM and $254MM raises; Fortis $4.2B acquisition of UNS; $2.4B acquisition of Novellus Systems; Eaton's $1.5B & $300MM capital raise. The SolarCity/Tesla transaction was also modified to $2.6B from the $4.864B included in the data set.
**Source**: BNEF (12/19/16)

# Solar Corporate Investment Activity, Global

- Global corporate solar investments in 2016 grew 24% y/y to $14.3B.
  - Most of the investments went to U.S. (33%) and European (44%) companies.
- 42% of global corporate investment came from public capital raises versus 3% in the United States.




**Notes**: Excludes Sharp's $4.6B credit facility & $1.2B secondary share placement; $13B acquisition of Algatec Equity Partners & Solar Thin Films Inc; $2.4B acquisition of Novellus Systems; PG&E $300MM and $254MM raises; Fortis $4.2B acquisition of UNS. The SolarCity/Tesla transaction was also modified to $2.6B from the $4.864B included in the data set.
**Source**: BNEF (12/19/16).

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- U.S. Deployment
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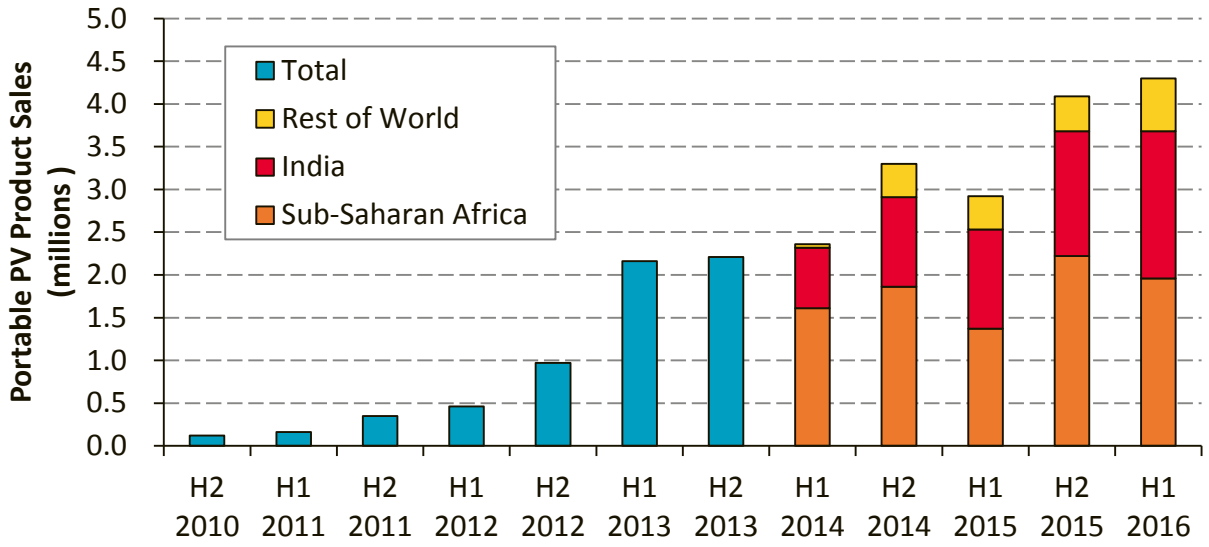
# Global Off-Grid Solar Market

- Approximately 1.2B people have no access to an electrical grid and spend $27B per year on lighting and mobile phone charging with kerosene, candles, flashlights, or other sources.
- Solar power technology has the potential to provide these services at a lower cost with fewer environmental impacts.
- 4.3MM portable solar products were sold in H1 2016 for $139MM.
  - Sales represent a 25X increase from H1 2011.
  - 23.5MM products cumulatively sold since 2010, providing over 100MM people with improved energy access and $4.3B in energy savings over the lives of the products.
  - 46% of sales in H1 2016 were in sub-Saharan Africa and 40% were in India.
- Off-grid solar product revenue is currently ~0.2% of the on-grid solar market; however, it has a much higher dollar-per-person impacted ratio.




**Source:** Global Off-Grid Lighting Association. "Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data: January – June 2016."

SunShot U.S. Department of Energy

energy.gov/sunshot

# Global Off-Grid Solar Market (cont.)

- Off-grid solar products offer varying degrees of service, from a single light to a solar home system.
  - In H1 2016, products with a capacity of less than 3 W represented 77% of reported sales.
- Product sales were reported by over 50 companies—44 of which are manufacturers, representing over 167 unique products.

| Product Size (Watts) | Use | % of H1 2016 Market Revenue* |
|---|---|---|
| 0 – 1.5 W | Single light only | 15% |
| 1.5 – 3 W | Single light & mobile charging | 45% |
| 3 – 10 W | Multiple lights & mobile charging | 28% |
| 11 – 20 W | Solar Home System (SHS), entry level (3-4 lights, mobile charging, powering radio, fan, etc.) | 10% |
| 21 – 49 W | SHS, basic capacity (above plus power for TV & extended capacity) | |
| 50 – 100 W | SHS, medium capacity (above but with extended capacities) | |
| 100+ W | SHS, higher capacity (above but with extended capacities) | |

**Source:** Global Off-Grid Lighting Association. "Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data: January – June 2016."

*Figures do not add to 100%.

# Thank You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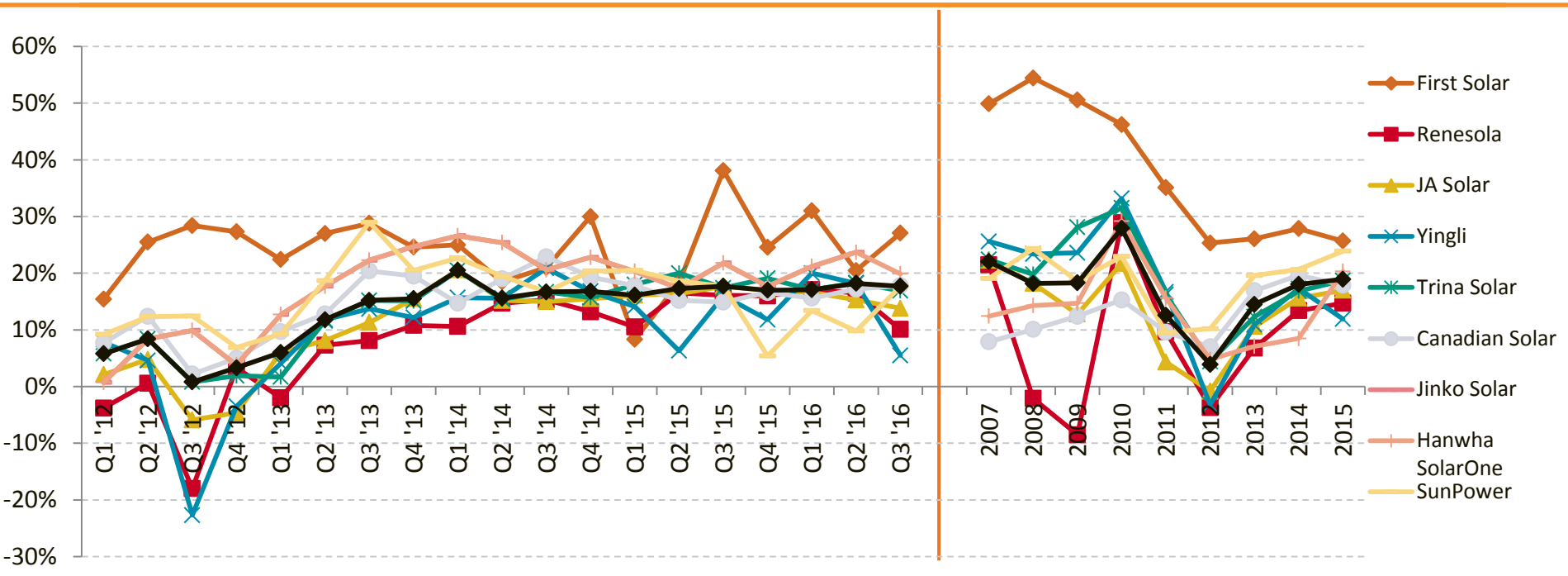
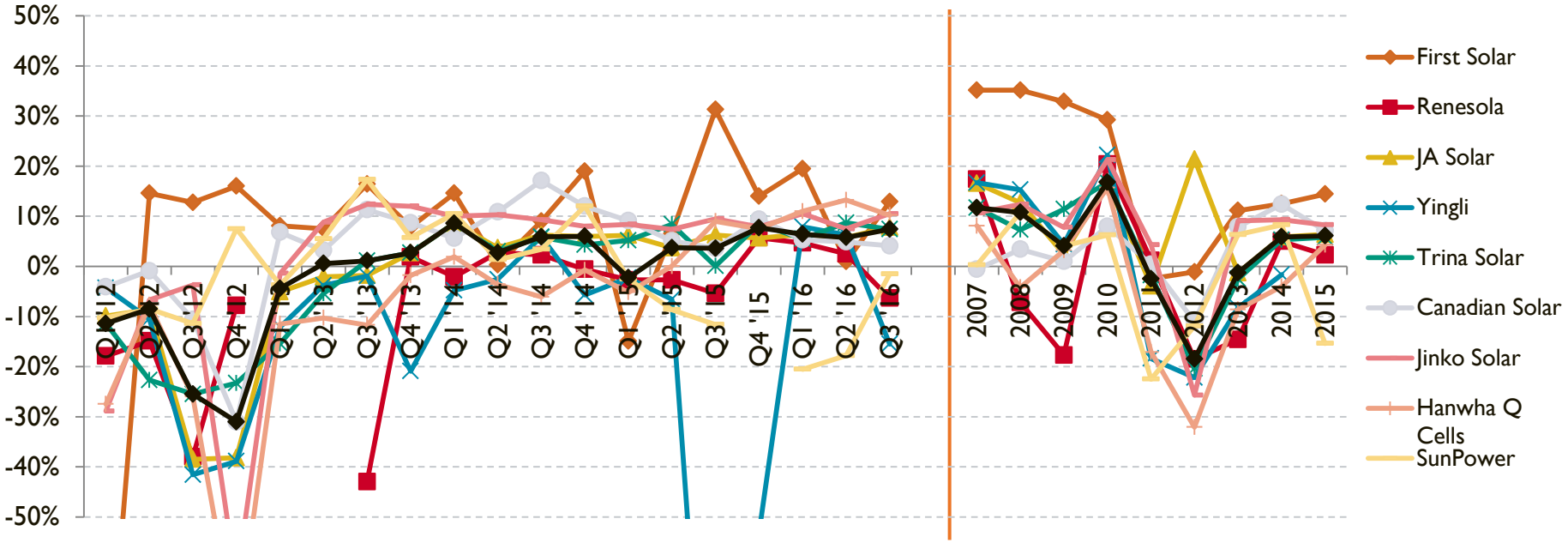
# PV Manufacturers' Gross Margins




- Industry gross margins are flat Q2–Q3 2016 with some variation among individual companies.
  - 18% median gross margin of above companies in Q3 2016
  - 18% in Q2 2016
  - 17% in Q1 2016
  - 18% in Q3 2015.

**Sources**: Company figures based on Q3 2016 (and previous) SEC filings by the respective companies.

# PV Manufacturers' Operating Margins

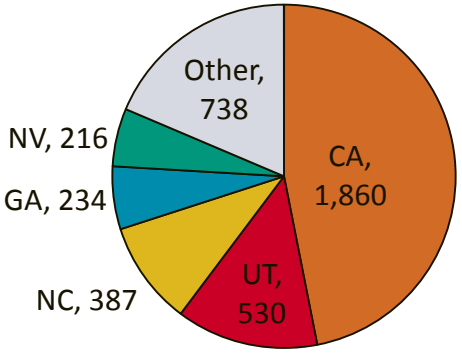



- Median operating margins rise 1% Q2–Q3 2016 with some variation among individual companies.
  - 7% median operating margin of above companies in Q3 2016
  - 6% in Q2 2016
  - 6% in Q1 2016
  - 4% in Q3 2015.

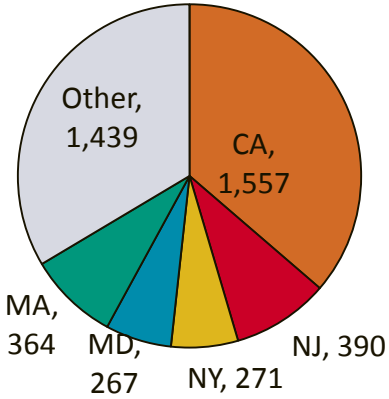
**Sources**: Company figures based on Q3 2016 (and previous) SEC filings by the surveyed companies.

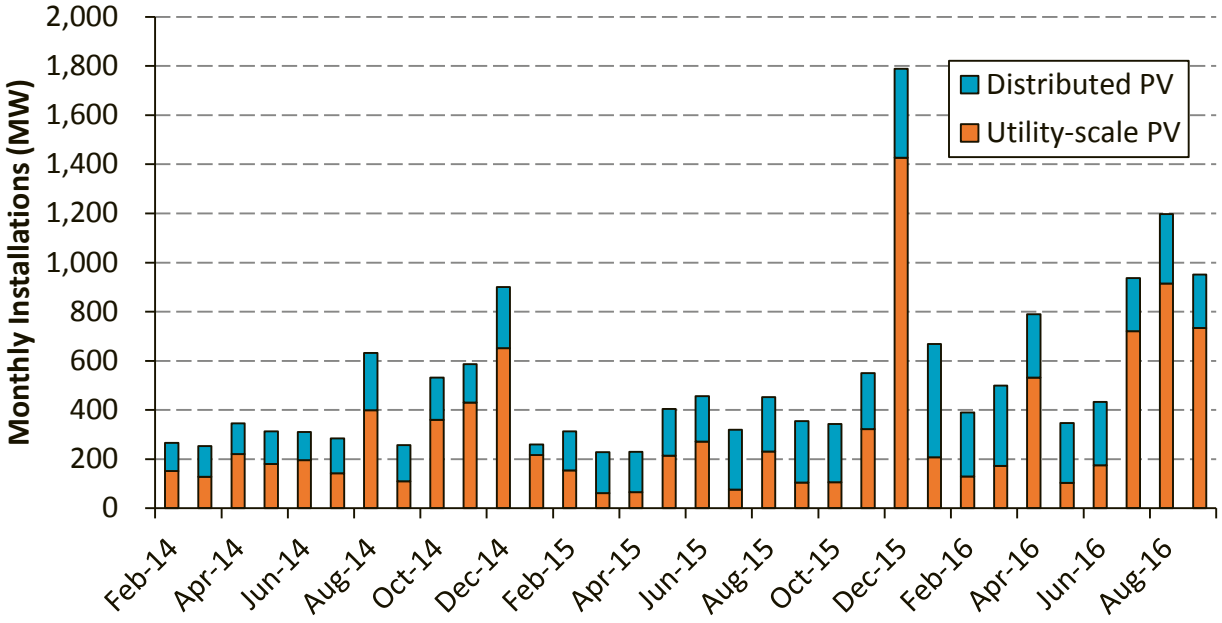
# U.S. Installation Breakdown

**U.S. PV Utility-Scale Installations by State ($MW_{AC}$), Q1-Q3 2016**




**U.S. PV Distributed Installations by State ($MW_{AC}$), Q1-Q3 2016**



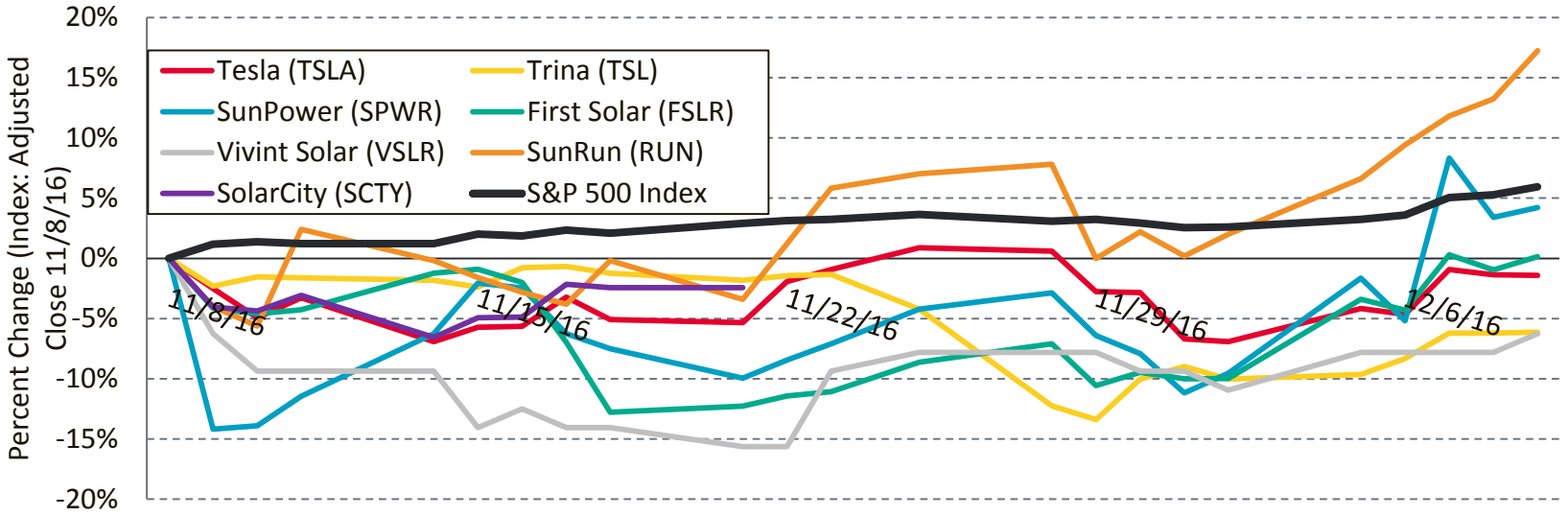




- The United States installed more than 1 $GW_{DC}$ of PV modules each month in Q3 2016.
- Utility-scale PV deployment has much greater seasonal variation than distributed PV deployment.

**Sources**: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861.

**Notes:** EIA monthly data for 2016 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported.

# Post- Elections Solar Stock Performance




- The effect of the election on solar stocks was relatively small compared to losses that occurred throughout the year.
  - Some solar stocks lost 5%-15% of their value; however, most of them have since recovered.
  - Many of these solar stocks had lost more value during 2016 prior to the election due to macroeconomic factors.

# List of Acronyms and Abbreviations

| | |
|---|---|
| ARRA | the American Recovery and Reinvestment Act of 2009 |
| ASP | average selling price |
| B | billion |
| BOS | balance-of-system |
| kW | kilowatt |
| kWh | kilowatt-hour |
| LMI | low-to-moderate income |
| MM | million |
| MW | megawatt |
| NEM | net energy metering |
| PPA | power purchase agreement |
| PURPA | Public Utility Regulatory Policies Act |
| Q/Q | quarter over quarter |
| ROW | rest of world |
| SI | systems integration |
| STH | solar thermal heating |
| SREC | solar renewable energy certificates |
| TTM | tech-to-market |
| W | watt |
| WACC | weighted average cost of capital |
| y/y | year over year |
| YTD | year to date |