NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Q4 2017/Q1 2018 Solar Industry Update

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May 2018

NREL/PR-6A20-71493

Executive Summary

- The United States installed 10.6 GW-DC of PV in 2017, 3.9 GW-DC in Q4—cumulative capacity reached 51.6 GW.
- After tariffs were placed on imported PV cells and modules, several countries have taken steps to dispute the proclamation and companies are seeking exemptions.
- Over 2 GW of new manufacturing capacity has been announced in the first 4 months of 2018, citing tariffs and corporate tax reductions.
- In 2017, the U.S. produced approximately 260 MW of PV cells and 970 MW of PV modules—a decrease of 66% and 43%, respectively, year over year.
- Global PV installations reached 415 GW-DC, an annual increase of 98 GW-DC from 2016.
- At the end of 2017, global CSP installations reached 5.6 GW, an increase of 400 MW.
- EIA reports that 32% of all new U.S. electricity generating capacity came from solar installations in 2017, though solar only represented 3.9% of net summer capacity and 1.9% of annual generation in 2017.
- From H2 2016 to H2 2017, EnergySage reported a 7% reduction in the average gross costs of a residential system to $3.13/W.
- In Q4 2017, total costs for Vivint- and Sunrun-built systems were between $2.65/W and $3.00/W.
- In a select data set of utility-scale PV systems, the median system price in 2017 was $2.16/W-AC ($1.66/W-DC).
- Global module ASP continues to decline to a low of 30 cents/W, while many manufacturers report module costs at similar values.
- U.S. module pricing traded at a premium in late 2017 due to tariff concerns.

A list of acronyms is available at the end of the presentation.

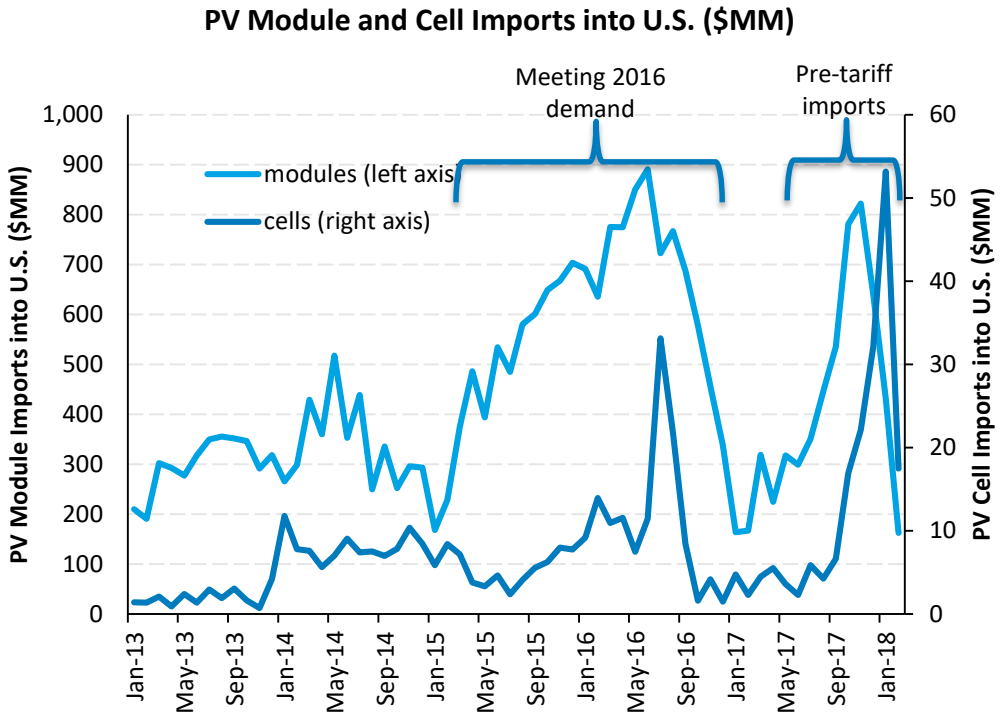
- **After tariffs were placed on imported PV cells and modules, several countries have taken steps to dispute the proclamation, and companies are seeking exemptions.**
- **Over 2 GW of new manufacturing capacity has been announced in the first 4 months of 2018, citing tariffs and corporate tax reductions.**
- **New Jersey increased its RPS to 50%, and Hawaii broke its utilities' link between revenue and capital investment.**

Section 201 Trade Case Update

- On February 7, 2018, the United States began imposing safeguard tariffs for imported c-Si PV cells and modules. The tariffs begin at 30% ad valorem in 2018 and decrease to 15% by 2021, with an exemption on the first 2.5 GW of imported PV cells per year.
- China, Taiwan, South Korea, Singapore, and the EU have begun taking steps with the WTO to dispute the tariffs. Three Canadian companies have also filed suit against the tariffs at the U.S. Court of International Trade.
- Dozens of companies have filed petitions for tariff exemptions; generally, the petitions argue that the products should receive an exemption because they are consumer and specialized products (e.g., solar-powered streetlights); have a unique module design (e.g., solar shingles, 72-cell design); have a unique cell design (e.g., IBC, bi-facial); or are integrated with other products (e.g., module plus inverter).
- GTM Research's updated U.S. PV deployment forecast in March 2018 was 13% lower than what was projected before the tariffs were put in place.
- In addition to the module and cell tariffs, the U.S. codified new steel (25%) and aluminum (10%) import tariffs, which GTM Research estimates will add an additional 2%–5% to PV system costs.

Sources: Greentech Median (February 2018); GTM Research (March 2018); PV Magazine (April 2018).

Section 201 Trade Case
Import Data



- Historically there have been spikes in imported PV cells and modules to meet increased levels of demand (e.g., 2016).
- The spike in imported PV cells and modules into the United States from August 2017 to January 2018 was likely done to avoid potential Section 201 tariffs.
  - The imports are particularly pronounced when considering the drop in global costs of cells and modules.
  - During that 6-month period, an estimated 8 GW of PV cells and modules were imported into the United States.

Sources: Imports, by value: U.S. International Trade Commission, 2018.

U.S. Manufacturing April Updates

- **JinkoSolar** confirmed it plans to invest $50MM to build a 400 MW module assembly plant in Jacksonville, Florida, to supply NextEra with 2.75 GW of solar modules over 4 years. Jacksonville city council had approved $24MM in incentives to attract a foreign manufacturer.

- **SunPower** announced it would purchase **SolarWorld Americas**. It plans to use the Oregon cell and module factory (currently with 430 MW of cell and 500 MW of module capacity) to manufacture its lower efficiency P-Series solar panels, as well as SolarWorld legacy products.
  - SunPower has petitioned the United States for an exemption on its imported PV products due to its unique IBC cell design, which makes it more expensive to manufacture. A day before SunPower's purchase of SolarWorld was announced it was revealed that SolarWorld backed SunPower's petition.

- **Suniva**'s creditors won court approval to sell the company's assets, including its solar manufacturing equipment, in a public auction. While Suniva's equipment has the possibility of being used again, the two original petitioners of the 201 trade case (Suniva and SolarWorld) are no longer a concern.

Sources: Greentech Media (April 2018); GTM Research (March 2018); PV Magazine (April 2018); Reuters (April 2018).

U.S. Manufacturing April Updates (cont.)

- **First Solar** announced it would make an initial $400MM investment in Ohio to build a 1.2-GW capacity plant to manufacture its large-format Series 6 modules, employing 500 workers.
  - This would triple its U.S. manufacturing capacity and bring its global manufacturing capacity to 7.6 GW (with plants in Malaysia and Vietnam).
  - Instead of the tariffs, First Solar cited recent U.S. tax reform and "favorable business environment" as reasons for its decision. It also said that its new large format cells reduce the labor benefits of producing panels abroad.
  - Their CEO said the new factory can also leverage its R&D and existing manufacturing in Ohio.

Sources: Greentech Media (April 2018); GTM Research (March 2018); PV Magazine (April 2018); Reuters (April 2018).

State Actions on Distributed Solar—Q1 2018

- 40 states and D.C. took 149 actions on distributed solar policy and rate design during Q1 2018.

Policy Type	# of Actions	% by Type	# of States
Residential fixed charge or minimum bill increase	49	33%	26
DG compensation rules	39	26%	25 + DC
DG valuation or net metering study	21	14%	17 + DC
Community solar	18	12%	15
Residential demand or solar charge	10	7%	5 + DC
Third-party ownership of solar	8	5%	3+ DC
Utility-led rooftop PV programs	4	3%	4
Total	**149**	**100%**	**40 States + DC**

- In January 2018, Massachusetts DPU approved Eversource's mandatory demand charge for new net-metering customers—the first mandatory residential demand charge by an IOU in the United States.
- A Montana utility, NorthWestern Energy, published a cost-benefit study, finding the net value of solar to be between $0.042/kWh and $0.046/kWh, including CO_2, and between $0.035/kWh and $0.038/kWh without.
- Utilities in North Carolina and Virginia proposed community solar programs in Q1 2018 and New Jersey passed legislation in April 2018, enabling the establishment of community solar programs.

Sources: North Carolina Clean Energy Technology Center, *The 50 States of Solar: Q1 2018 Quarterly Report*, April 2018. PV Magazine (April 2018).

State Actions on Solar—April 2018

- Michigan PSC replaced its net-metering system with one that credits exported energy at “avoided cost.”
- Florida PSC voted to allow Sunrun to sell its lease product in the state. Florida still bars the third-party sale of electricity, but Sunrun made changes to its contract, including removing its performance guarantee.
- Hawaii governor signed a law mandating performance-based utility regulation, breaking the link between utility revenues and capital investments. The new business model will base revenues on metrics like customer satisfaction, renewable energy integration, and data sharing.
- New Jersey passed legislation to increase its RPS to 50% by 2030 and behind-the-meter solar to 5.1% by 2021.
  - The bills close the SREC program in 2021 and direct regulators to move to a different program for distributed solar.
  - The bill sets storage targets of 600 MW in 2021 and 2 GW in 2030 and enables the establishment of community solar programs.

Sources: Greentech Media (April 2018); PV Magazine (April 2018); UtilityDive (April 2018).

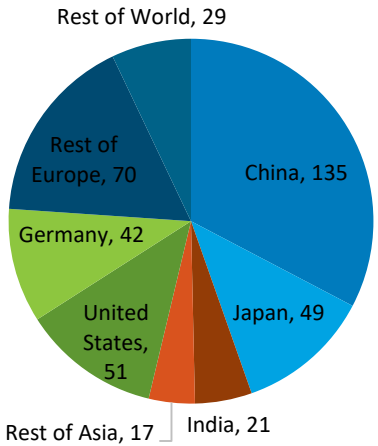
- **Global PV installations reached 415 GW-DC, an annual increase of 98 GW-DC from 2016.**
- **By the end of 2017, China had over 130 GW of cumulative PV installations, an annual increase of 53 GW.**
- **At the end of 2017, global CSP installations reached 5.6 GW, an increase of 400 MW.**

Top PV Markets

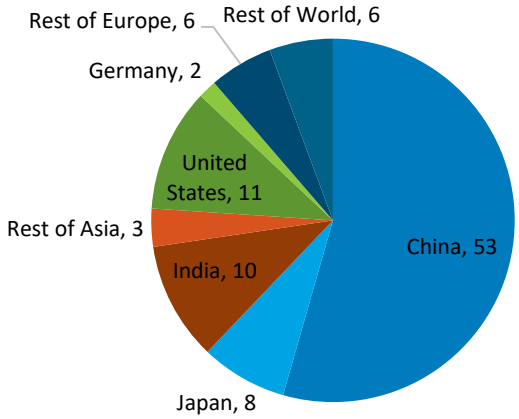
- At the end of 2017, global PV installations reached 415 GW-DC, an annual increase of 98 GW-DC from 2016.
- The leading five markets, in cumulative and annual PV installations at the end of 2017, were China, the United States, Japan, India, and Europe.

- By the end of 2017, China had over 130 GW of cumulative PV installations, an annual increase of 53 GW—approximately the same as the next three markets combined.
- In 2017, the United States had the second-largest PV market in terms of annual and cumulative installations.
- India grew annual PV deployment from 2 GW in 2015 to 10 GW in 2017.

Cumulative PV Deployment - 2017 (415 GW)



Annual PV Deployment - 2017 (98 GW)



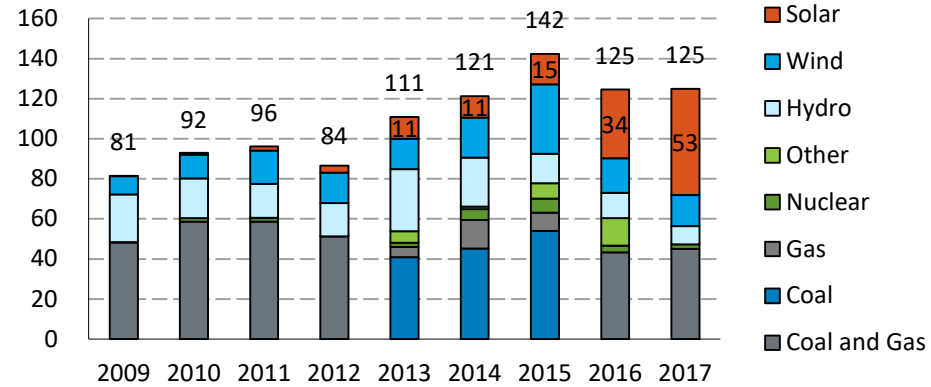
Source: BNEF (2018).

Chinese Generation Capacity Additions by Source

- In 2017, solar contributed 42% to new generation capacity in China (53 GW) and 7% of cumulative capacity (130 GW).
  - 2017 is the first year that wind and solar contributed over half of all new electric generation in China (55%).
  - Chinese annual electric generation capacity additions have been around six times greater than additions by the United States for the past 5 years.

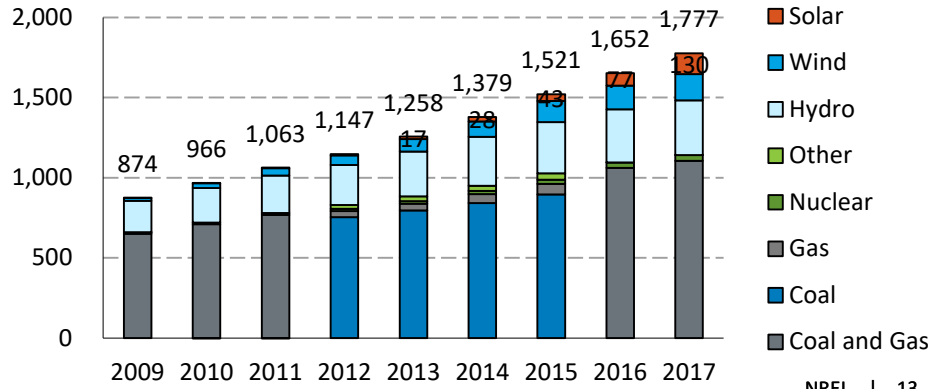
- As China grows its electricity infrastructure, it has rapidly incorporated non-carbon sources of electricity generation.
  - Since 2009, China has doubled its installed electric generation capacity, and at the same time reduced the percentage of total coal and gas capacity from 74% to 62%.
  - From 2010 to 2016, new thermal generation capacity as a percent of total new capacity was reduced from 63% to 36%.

Annual Capacity Additions (GW)



Source: China Electric Council, accessed (2017, 2018).

Cumulative Capacity (GW)



Chinese Market Update

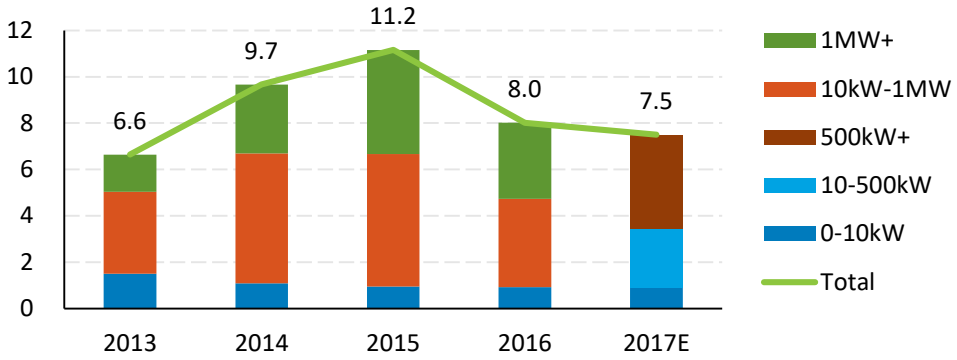
- BNEF attributes China's record 53 GW of new PV in 2017 to the sudden increase in quota allocation by the Chinese government in August 2017.
  - The new quota called for 86.5 GW of new utility-scale PV by 2020, with 32 GW coming from "top-runner" installations (which projects use "best-in-class" technologies and are determined by auction).
  - China installed 9.65 GW of PV in Q1 2018.
- Of the 130 GW of PV installed at the end of 2017, BNEF estimates that 30 GW were distributed PV (70% of which were located on rooftops).
  - Going forward, BNEF expects a higher percentage of rooftop PV systems in China, which, unlike ground-mounted projects, have no quota, higher subsidies, and a lower risk of subsidy payment delays.
- At the end of 2017, China announced a 12%-15% FiT cut for projects installed after June 2018. Another FiT cut is expected in January 2019; therefore, BNEF expects an installation rush in Q2 and Q4 of 2018.
- Regulatory restructuring in 2018 centralized zoning and resource permitting, which should contract project development timelines.
- BNEF reports that policies supporting greater renewable integration, along with power demand growth, helped reduce solar curtailment to 6% in 2017.
  - However, certain regions suffer from curtailment as high as 16%; to address this, China has reduced build-quotas in these regions.

Source: BNEF, "1H 2018 China Market Outlook." March 2018.

Japanese Market Update

- BNEF estimates that approximately 7.5 GW of PV was installed in Japan in 2017, bringing cumulative deployment to 49 GW.
- While Japan's PV industry had focused in the residential sector before the FiT, it is relying more heavily on larger projects.
- Japan held its first solar auction in 2017; however, only 141 MW of a possible 500 MW were successful. Japan is hoping with less strict rules, two more auctions for up to 250 MW of PV projects larger than 2 MW, will be successful in 2018.

Annual Japanese PV Deployment (GW-DC)

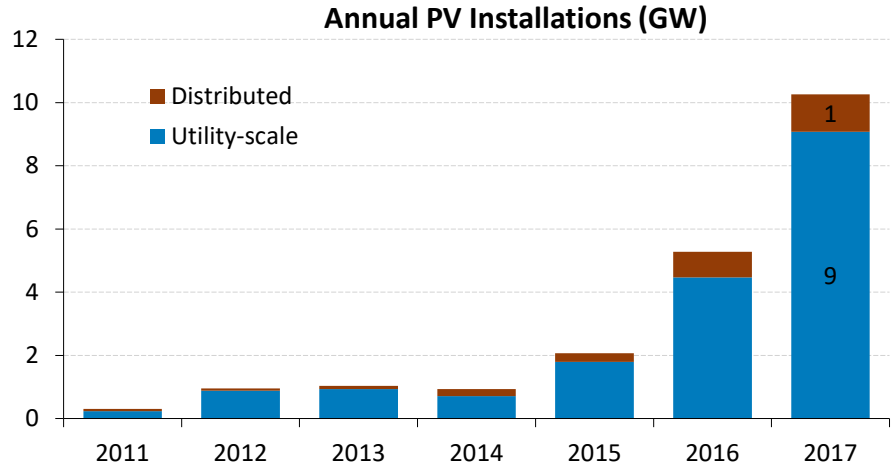


Source: BNEF, "1H 2018 Japan Market Outlook." March 2018.

- Starting in July 2016, projects must secure grid connection approval within 9 months of their FiT approval. Japan has thus far revoked FiT allocations from 15 GW of mostly PV projects.
- As Japanese households come off their FiT, there is new interest in finding ways to optimize solar use. A Japan utility and university introduced a trial "virtual power plant," which shifts heat pump use from night to the middle of the day if excess PV production is predicted. Japan currently has more than 5 million heat pumps.
  - Japan installed 149 MWh of energy storage in 2017, bringing its total to approximately 1.2 GWh (along with record EV sales).
  - Curtailment occurred 42 times in 2017 (compared to 17 in 2016) however, all were on remote islands in periods of low demand.
- In 2017, imported coal reached an all-time high and LNG imports increased as nuclear starts were delayed.

Indian Market Update

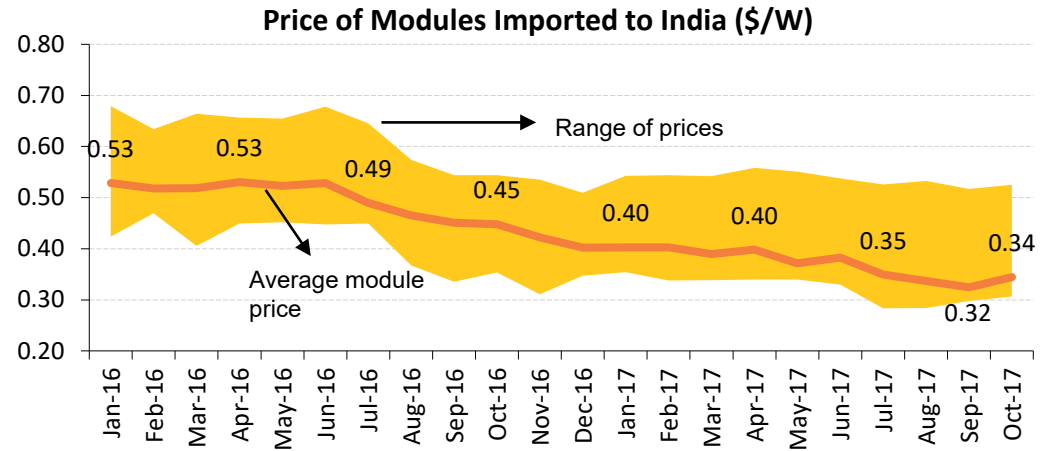
- BNEF estimates that approximately 10 GW of PV was installed in India in 2017, bringing cumulative deployment to 21 GW.
- An increase in module prices and the ambiguity over tax rates delayed installation of several projects in H2 2017.
- India aims to bring 80 GW of PV (and 28 GW of wind) to auctions in 2018 and 2019 as they try reach their 175 GW target of renewables by March 2022.



- The Indian government has not yet given clarity to solar project developers on the final goods and service tax rates applicable to various solar components, causing uncertainty to project economics.
- As solar auctions have become fewer and more competitive, Indian IPPs are pursuing ways of raising cheaper capital through mergers and acquisitions, IPOs, or through selling existing portfolios of operating projects. Indian firms raised $712 million in new equity investments and another $3.8 billion through green bonds in 2017.
- Four Indian States have finalized regulations that penalize renewable energy power producers for being unable to forecast electricity generation within 15%.

Source: BNEF, "1H 2018 India Market Outlook." January 2018. BNEF, "Capacity & Generation" data set. Accessed April 23, 2018.

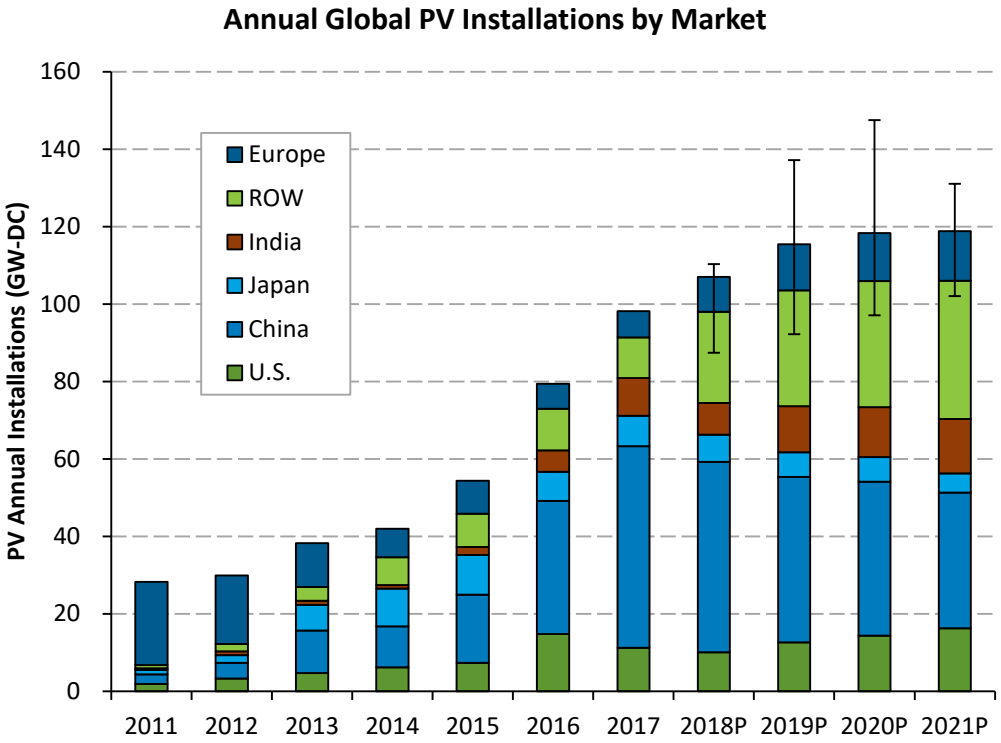
Indian PV Manufacturing Update



- In July 2017, India initiated an anti-dumping investigation regarding modules manufactured in China, Malaysia, and Taiwan. In January 2018, a preliminary recommendation of a 70% safeguard duty was announced, which developers felt would severely impact the industry. In March 2018, Indian manufacturers announced they were withdrawing their petition so that they could refile with more contemporary data, causing India to terminate their investigation. Indian manufacturers plan on filing a new petition this year.
  - Electricity contracts auctioned in H2 2017 ranged between $38/MWh and $64/MWh—up to 68% higher than some bids in H1 2017.
- Due to fears of Indian module quality, the government issued orders to establish quality control standards for solar equipment. The order bans the manufacturing or sale of equipment that has not achieved these standards. The standards took effect April 1, 2018.

Source: BNEF, "1H 2018 India Market Outlook." January 2018.

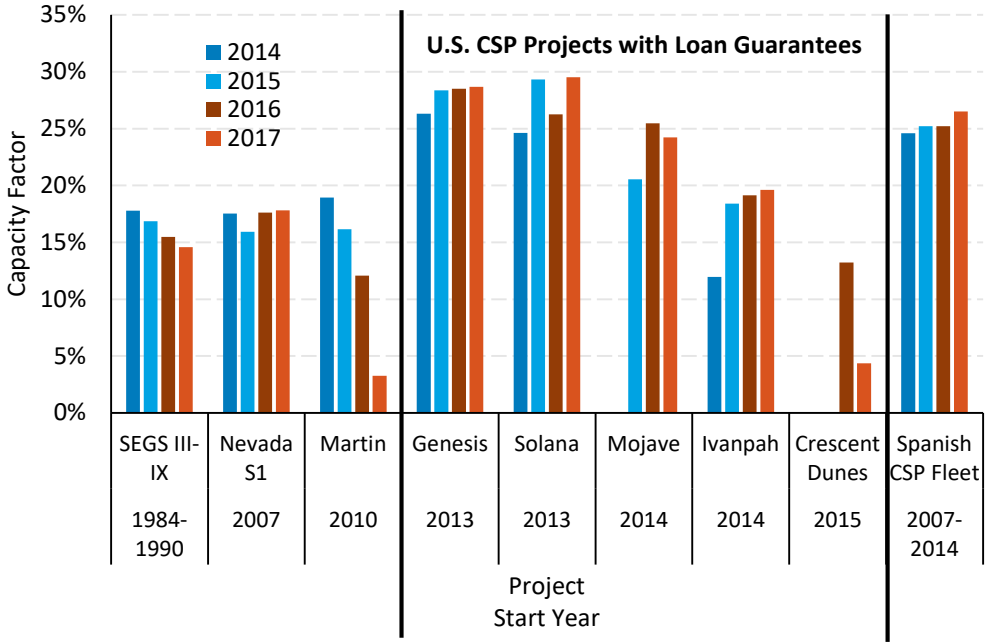
Annual Global PV Demand



- While most analysts estimate an increase in PV installations in 2018, projections range from 87 GW to 111 GW.
- In 2018, analysts expect China (~50 GW), the United States (~10 GW), and India (~8 GW) to remain the three largest markets; however, ROW is expected to significantly expand.
- Through 2021, analysts expect China to remain the largest PV market; however, they are expected to gradually contract while other markets expand.
  - Chinese market growth represented approximately all of global PV market growth in 2017 and over 50% of market growth in 2015 and 2016.
- The median analyst figures estimate that 460 GW of PV will be installed globally from 2018 to 2021, more than doubling current installed capacity.

Note: P = projection. Bar represents median projection. Error bars represent high and low projections.
Sources: BNEF (April 2018); Deutsche Bank (01/05/18); Goldman Sachs (01/09/18); GTM Research (January 2018).

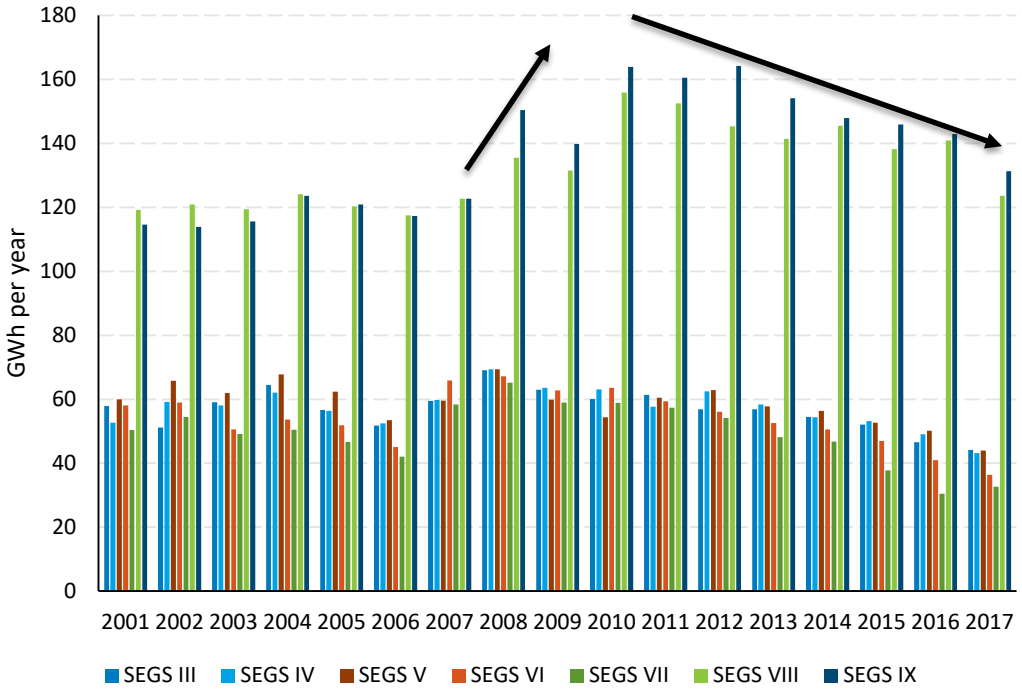
U.S. and Spanish CSP Project Generation Performance, 2014-2017



- Four of the five recent U.S. CSP projects, which received loans guarantees from the U.S. Department of Energy, continue to improve operations and increase system production.
- Crescent Dunes continued to face operation challenges in 2017.
  - UtilityDive reported in July 2017 that after 8 months offline, caused by a leak in a container of molten salt, the plant was back online.
  - Crescent Dunes, a power tower with 10 hours of storage, represents the newest technology; therefore, time spent learning how to optimize operation was expected.
- The average capacity factors for Spanish CSP plants continue to increase, as plant owners also learn to operate more efficiently.

Sources: Mark Mehos. EIA, "Electric Power Monthly" 1.1, 1.1A; 2018; EIA, "Monthly Energy Review" (2018); TSO (REE); UtilityDive (July 2017).

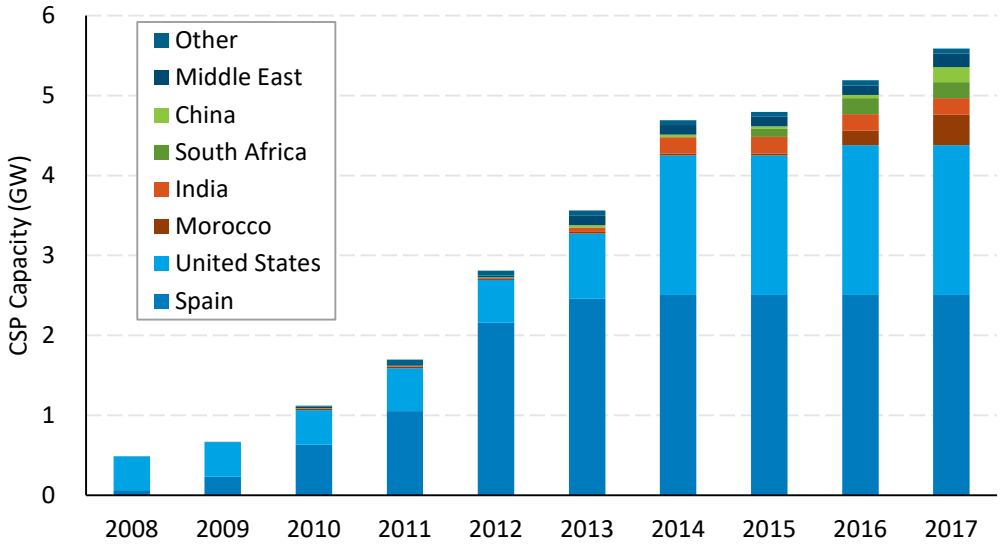
SEGS III – IX Production, 2001-2017



- In 2008, SEGS plants started replacing their receivers due to hydrogen build-up, which increased system performance from 2007 to 2008.
- Since then, receiver performance has continued to drop.
- DOE and NREL are currently developing a system to scrub the hydrogen in order to improve performance again.

Sources: Mark Mehos. EIA, "Electric Power Monthly" 2018.

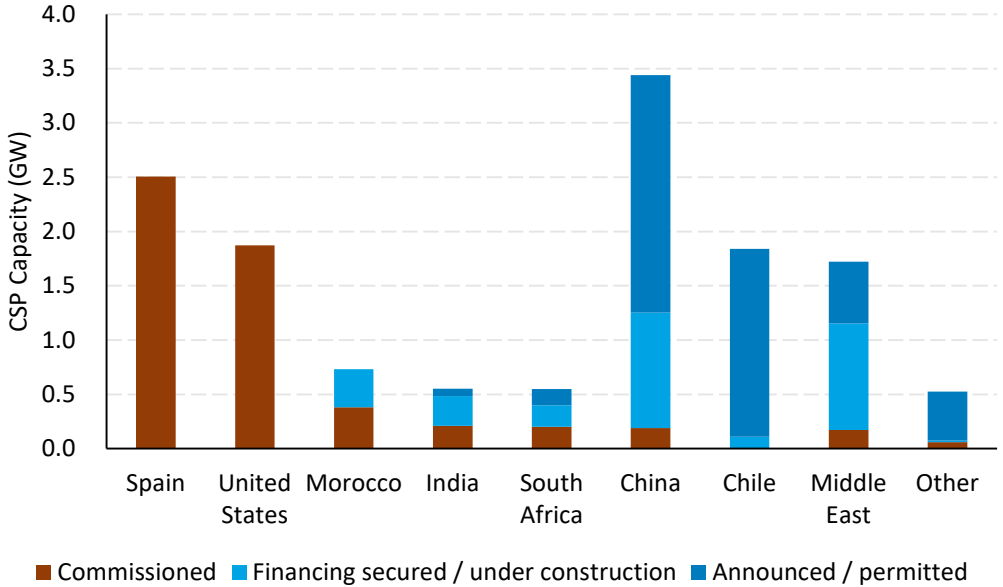
Global CSP Installed



- At the end of 2017, global CSP installations reached 5.6 GW.
- 400 MW total were added in 2017 from Morocco, China, and Kuwait.
- The majority of CSP is still located in Spain and the United States, but other countries' global market share has grown from 4% in 2012 to 22% in 2017.

Source: BNEF, "Capacity & Generation" data set. Accessed April 23, 2018.

Global CSP Pipeline



- While Spain and the United States are global market leaders in CSP, there are currently no active projects in development.
- The areas with the largest solar development are China, Chile, the Middle East, and North Africa.
- A recent analysis by New Energy Update found that CAPEX costs from 16 recent CSP projects were almost half of those from projects installed from 2013 to 2015.
  - New capital costs ranged from $3.9/W to $6.4/W, with 6 to 16 hours of storage.
  - Reduction in costs were attributed to the growth of towers with storage, better project design, lower labor and component costs (e.g., in and from China), greater energy storage volume, and increased project size.

Sources: BNEF, "Capacity & Generation" data set. Accessed April 23, 2018; CSP Today (April 16, 2018). Data updated to include 110 MW Chile project, Atacama 1, in construction.

CSP Tower Projects Expected to Come Online by the End of 2018

Plant name	Status	Country	Technology	Storage hours	Capacity (MW)	CAPEX ($M, $/kW)	PPA ($/kWh)
Khi Solar One	Operating	South Africa	Steam Tower	2 (steam accum.)	1 x 50 MW	$445MM $8,900/kW	$0.236
Noor III	Commissioning	Morocco	Molten Salt Tower	7.5	1 x 150 MW	$862MM $5,747/kW	$0.154
Ashalim Plot B	Construction	Israel	Steam Tower	0	1 x 121 MW	$750MM $6,198/kW	
Golmud	Construction	China	Molten Salt Tower	15	2 x 100 MW	$853MM $4,265/kW	
Shouhang Dunhuang	Construction	China	Molten Salt Tower	11	1 x 100 MW	$486MM $4,860/kW	
Supcon Delingha	Construction	China	Molten Salt Tower	6	1 x 50 MW	$167MM $3,330/kW	

- Six power tower projects totaling 671 MW of capacity are expected to come online in 2018.
  - Projects use both steam and molten salt technologies.
  - Projects incorporate energy storage ranging from 0 hours to 15 hours.
  - CAPEX costs range from $4,265/kW to $8,900/kW.
  - Available PPA information ranges from $0.15/kWh to $0.24/kWh.

Sources: Parthiv Kurup; New Energy Update (2018); NREL and SolarPaces (2016); Megalim Solar Power (2017); Relloso and Gutiérrez (2017); CSP Plaza (2018).

CSP Tower Projects Expected to Come Online From 2019-2021

Plant name	Status	Country	Technology	Storage hours	Turbine Capacity	CAPEX ($M, ($/kW)	PPA ($/kWh)
Atacama 1	Construct.	Chile	Molten Salt Tower	17.5	1 x 110 MW	$1,300MM $11,810/kW	
Gansu Jinta (3 Gorges)	Construct.	China	Molten Salt Tower	8	1 x 100 MW	$400MM $4000/kW	$0.181
Yumen Huahai	Planning	China	Molten Salt Tower	10	1 x 100 MW	$381MM $3807/kW	$0.181
Aurora	Planning	Australia	Molten Salt Tower	8	1 x 150 MW	$650MM $4333/kW	$0.078
Likana 1,2 and 3	Planning	Chile	Molten Salt Tower	13	3 x 130 MW	$800MM $6154/kW (estimate for one unit)	
DEWA CSP Project - Unit 1	Develop.	Dubai	Molten Salt Tower	15	1 x 100 MW	$540MM $5400/kW*	$0.073
Redstone	Develop.	South Africa	Molten Salt Tower	12	1 x 100 MW	$749MM $7490/kW	$0.124/kWh for the 1st year, then $0.15/kWh after

- Seven additional molten salt tower projects totaling 1.1 GW of capacity are expected to come online between 2019 and 2021.
  - Projects incorporate energy storage ranging from 8 hours to 18 hours.
  - CAPEX costs range from $3,807/kW to $11,810/kW.
  - Available PPA information ranges from $0.07/kWh to $0.18/kWh.

Sources: Parthiv Kurup; ACWA Power (2017); CSP Kip (2017); New Energy Update (2018); NREL and SolarPaces (2016); Megalim Solar Power (2017); Relloso and Gutiérrez (2017); CSP Plaza (2018); SolarReserve (2018).

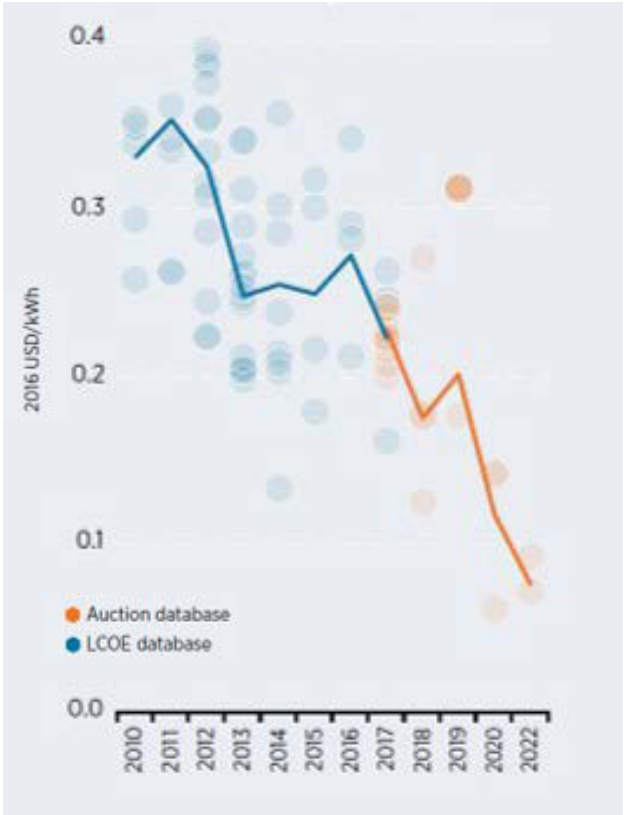
Global CSP Cost and Performance

CSP installed costs, capacity factor, and LCOE, 2010-2017

- IRENA reported 2017 global-weighted average installed costs and LCOE for CSP fell 27% and 33% from 2010 to 2017, respectively.

Sources: IRENA, "Renewable Power Generation Costs in 2017."

Global CSP LCOE



- Despite a global average LCOE of $0.22/kWh in 2017, IRENA reports that recent auctions will put CSP pricing between $0.06/kWh and $0.10/kWh by 2022.

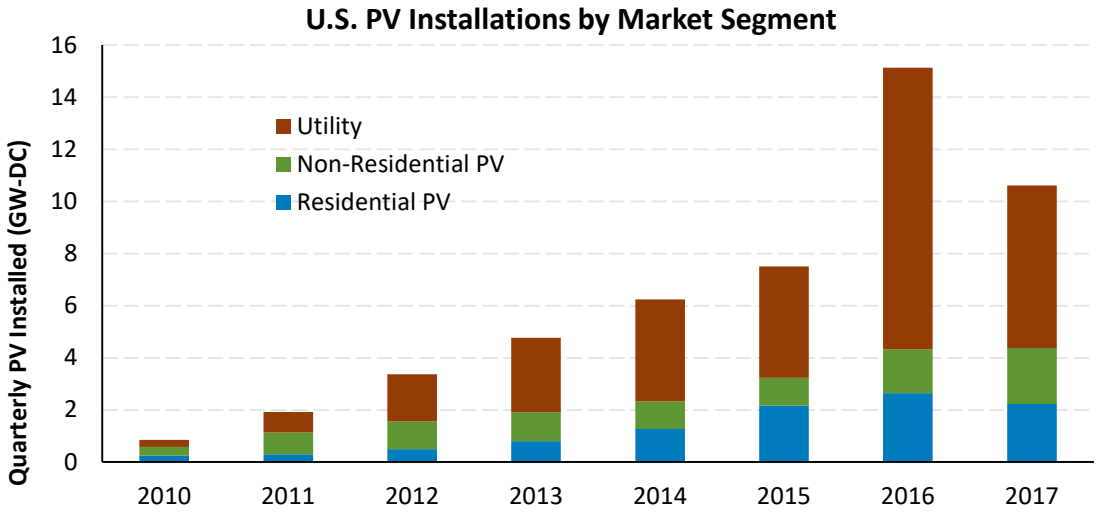
Sources: IRENA, "Renewable Power Generation Costs in 2017."

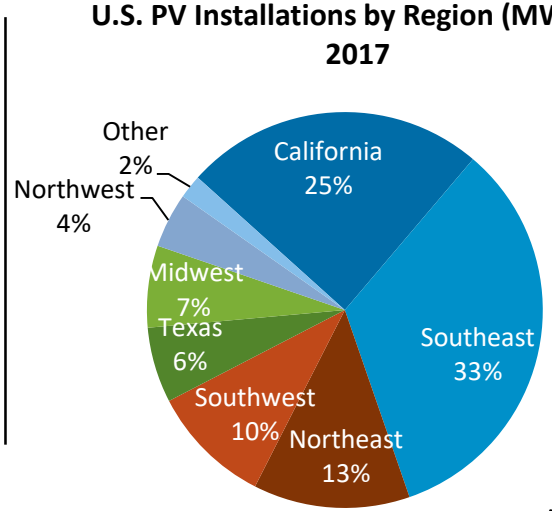
- **The United States installed 10.6 GW-DC of PV in 2017, 3.9 GW-DC in Q4—cumulative capacity reached 51.6 GW.**
- **EIA reports that 32% of all new electricity generating capacity came from solar installations in 2017—second to natural gas.**
- **At the end of 2017, solar represented 3.9% of net summer capacity and 1.9% of annual generation.**
- **Analysts estimate U.S. solar installations in 2018 will be between 7.5 GW and 10.8 GW, with most analysts expecting further market contraction.**

U.S. Installation Breakdown

- The United States installed 10.6 GW-DC of PV in 2017, 3.9 GW-DC in Q4—cumulative capacity reached 51.6 GW.
  - Despite installing 30% fewer GWs in 2017 than in 2016, it still represents a 40% growth over 2015 installations.

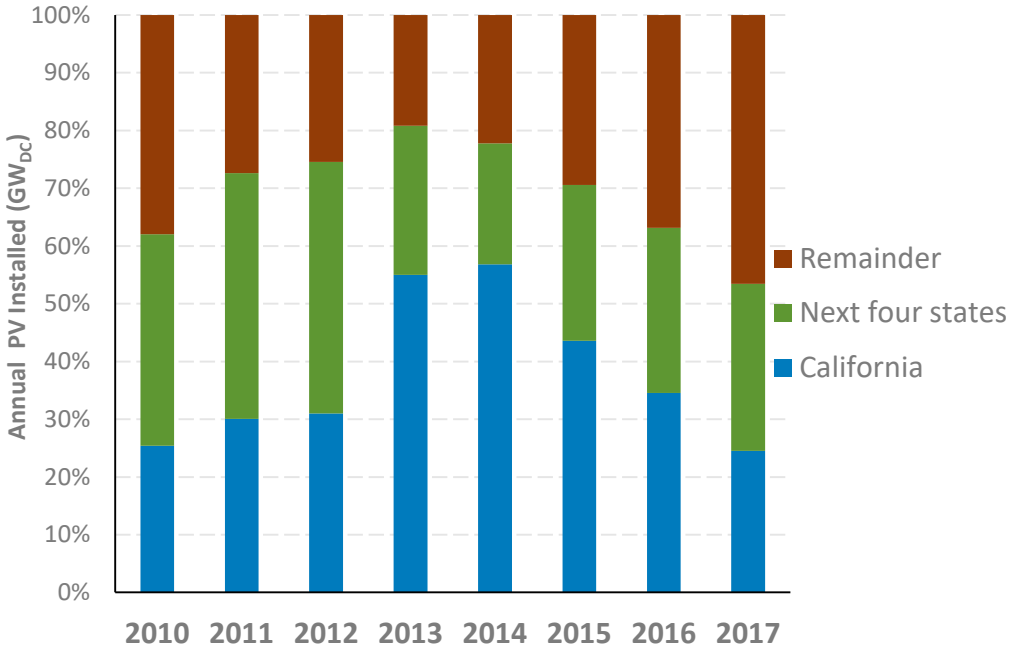
- GTM Research reports that many utility-scale projects were shelved in 2017 due to uncertainty surrounding Section 201 tariffs. However, the drop-off, year-over-year, was largely caused by the pipeline depletion in 2016 due to expectations of an expiring 30% ITC (which was extended).
- U.S. residential PV has had customer acquisition challenges amidst widespread NEM reform, loss of state incentives, and potential saturation of early adopters.
- In 2017, new PV installations have had a fair geographic mix across the United States, with 5 GW-DC installed east of the Mississippi.





Sources: GTM Research/SEIA: U.S. Solar Market Insight 2017 Year-in-Review.

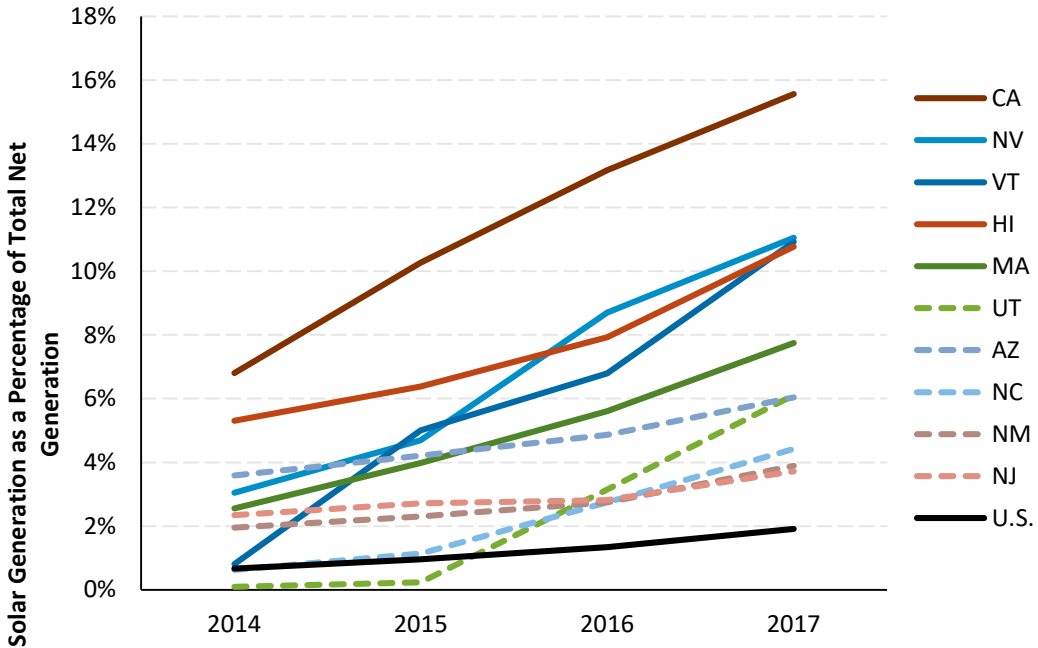
U.S. Installation Breakdown



- The top five states represented approximately 53% of the U.S. PV market in 2017—the lowest level in at least 12 years.
  - Part of that reason is that in 2017, the California market contracted, y/y, for the first time in over 12 years.
  - States outside of the top five contracted 11% from 2016 to 2017; however, installed capacity was still 124% higher than 2015 values.

Sources: GTM Research/SEIA: U.S. Solar Market Insight Q4 2017.

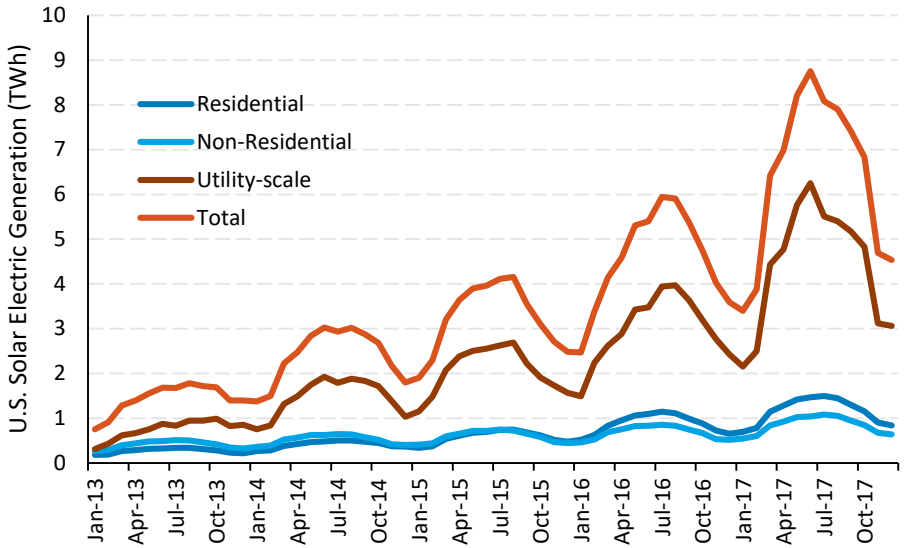
Solar Generation as a Percentage of Total Generation, 2014-2017



Note: EIA monthly data for 2017 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. "Net Generation" includes DPV generation. Net generation does not take into account imports and exports to and from each state and therefore the percentage of solar consumed in each state may vary from its percentage of net generation.
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (February 2018).

- The 10 states with the highest percentage of solar penetration generated at least 3.5% of their energy from solar in 2017, with California leading the way at 15.6%.
  - In 2014, California led the United States with 6.8% of total generation coming from solar.
  - Utah's percentage of electricity generation coming from solar grew from 0.2% in 2015 to 6.1% in 2017.
- In 2017, the United States as a whole produced approximately 1.9% of its electricity using solar technologies.
  - This represents an approximate 2X growth from 2014 (0.7%).

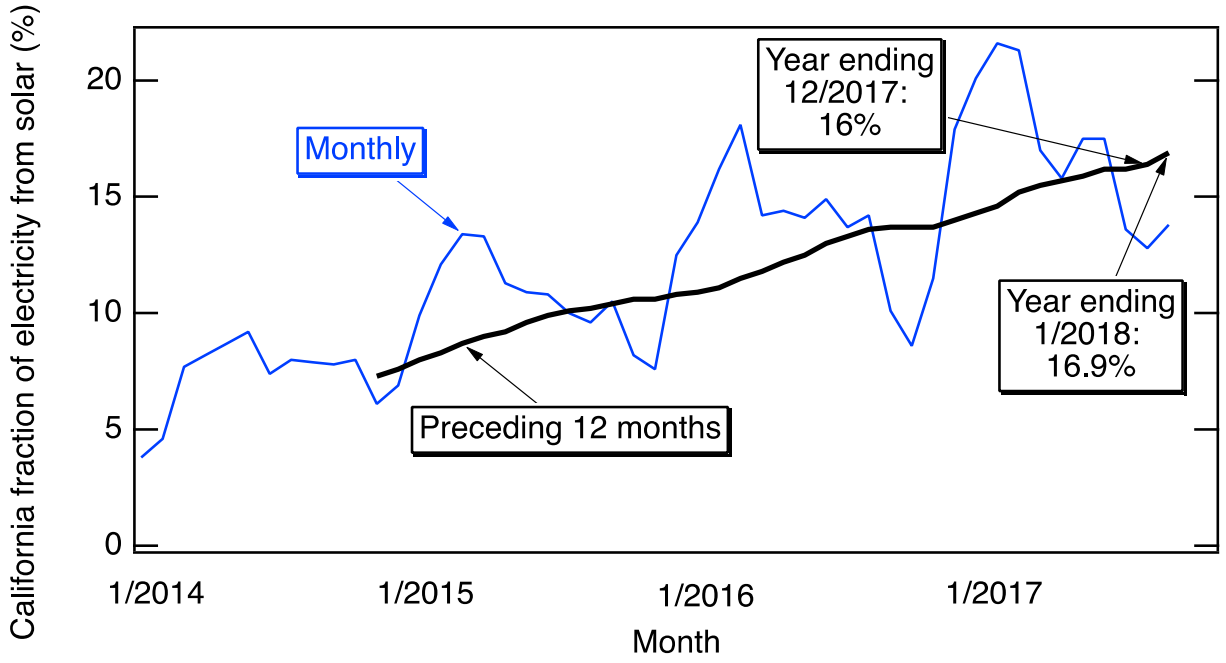
Monthly U.S. Solar Generation, 2013-2017



- Total peak monthly U.S. solar generation increased by a factor of four from 2013 to 2017.
  - U.S. electric generation in December 2017 (during the low seasonal period of electric generation) was well above peak solar production in 2015.
  - In May 2017, solar produced 2.5% of total U.S. electricity production.
- Utility-scale solar electricity production (including PV and CSP technologies) has generally dropped by approximately 40% to 50% from summer to winter, while distributed PV systems dropped 30% to 40%.
  - This drop in production would likely be exacerbated without continued build of solar installations throughout the year.

Note: EIA monthly data for 2017 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. "Net Generation" includes DPV generation.
Sources: EIA, "Monthly Energy Review," (March 2018).

California Has Taken Solar to a New Level–What Can We Learn From Their Experience?

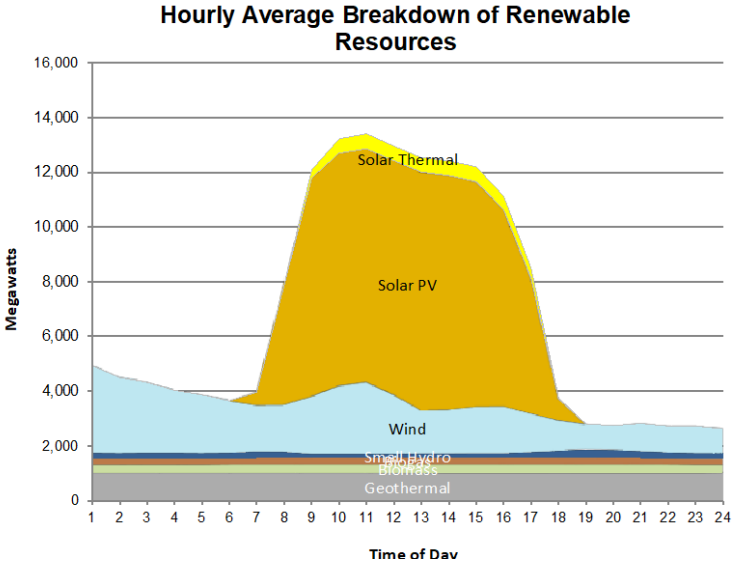


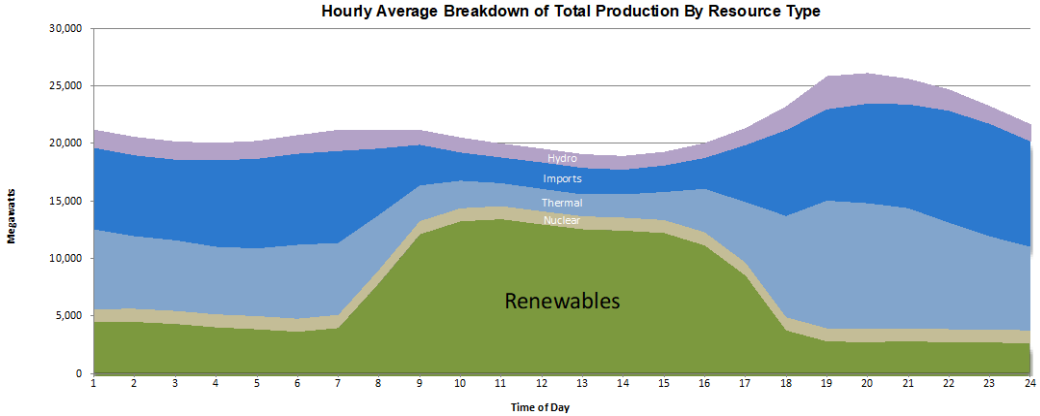
Source: Sarah Kurtz. EIA.

In California, Sometimes Non-Hydro Renewable Electricity is > 50%

- Similar to Germany, much of the balancing is done using imports.
  - 6 GWh (~1% of total) were curtailed, and 2 GWh were exported on April 8, 2018.

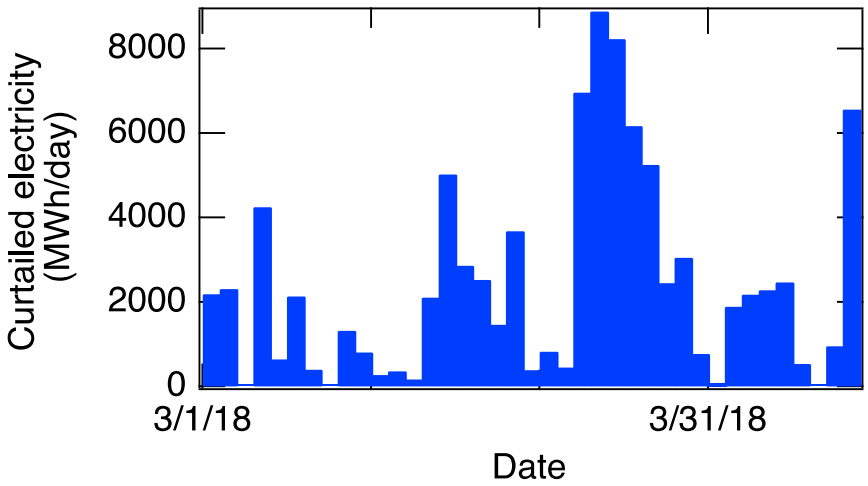
- California's all-renewable electricity hit 83% from 1 p.m.-2 p.m. on April 8, 2018 (54% for day).
  - ~9 GW (47%) came from solar electricity.
  - ~13 GW (68%) came from non-hydro renewable electricity.
  - 19-20 GW of total demand.





Source: Sarah Kurtz. http://www.caiso.com/market/Pages/ReportsBulletins/DailyRenewablesWatch.aspx

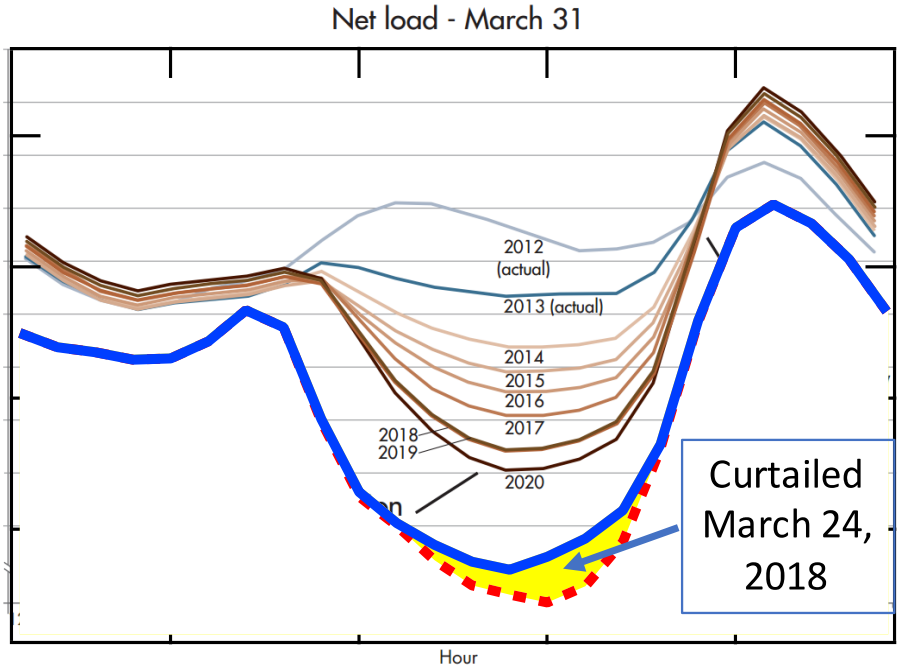
Curtailed Electricity in California in 2018



- As of April 8, 2018, the curtailed electricity year-to-date in California was 132,728 MWh.
- If that electricity is valued at $0.10/kWh, curtailment results in ~$13MM in lost revenue.

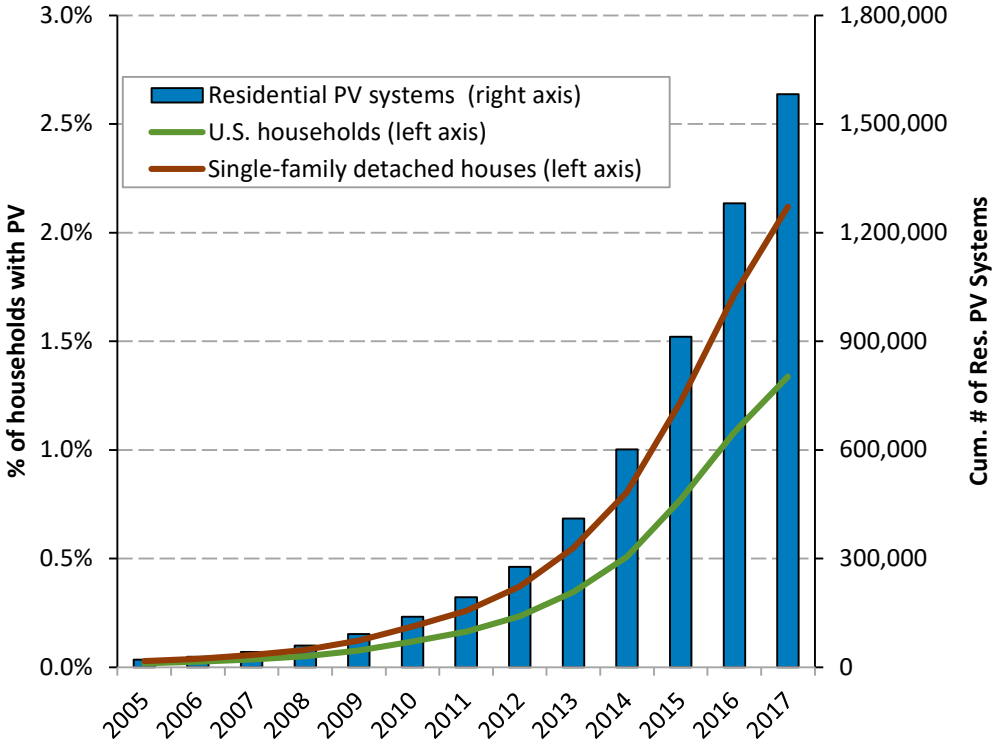
Source: Sarah Kurtz. http://www.caiso.com/market/Pages/ReportsBulletins/DailyRenewablesWatch.aspx

Watching the Duck Grow Fat



Source: Sarah Kurtz. http://www.caiso.com/market/Pages/ReportsBulletins/DailyRenewablesWatch.aspx

U.S. Residential PV Penetration

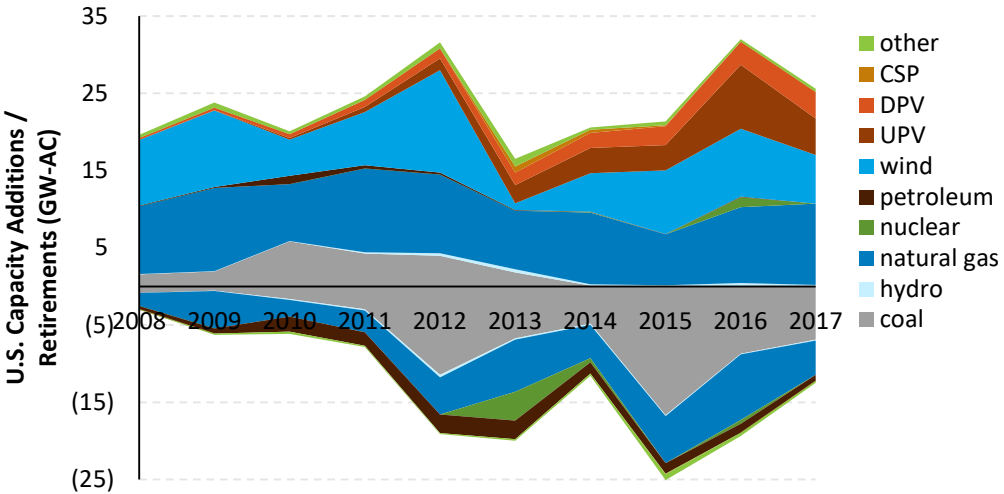


Sources: Res. PV Installations: 2000-2009, IREC 2010 Solar Market Trends Report; 2010-2017, SEIA/GTM Solar Market Insight 2017 Year-in-Review; U.S. Households U.S. Census Bureau, 2015 American Housing Survey; state percentages based on 2000 survey.

- Since 2005, when the investment tax credit was passed by congress, the residential PV market has grown by approximately 44% per year, or about 81X.
- At the end of 2017, there were approximately 1.6 million residential PV systems in the United States.
- Still, only 1.3% of households own or lease a PV system (or about 2.1% of households living in single-family detached structures).
- However, solar penetration varies by location. Hawaii, California, and Arizona have residential systems on an estimated 31%, 11%, and 9% of households living in single-family detached structures.

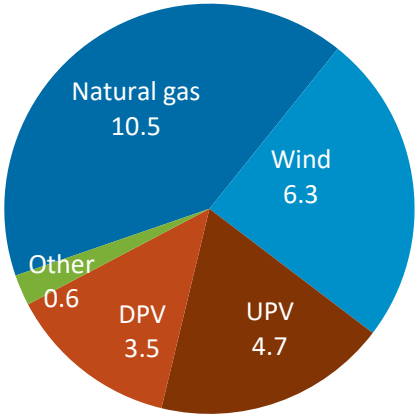
U.S. Generation Capacity Additions by Source

- The United States has installed ~23 GW of new capacity per year in the past decade, while retiring ~18 GW annually in the past 5 years—the retirements are mostly gas plants, which are being replaced, and coal plants.
- It would take 50-60 years to change the entire U.S. generation fleet at the current pace of replacement.



- EIA reports that 32% of all new electricity generating capacity came from solar installations in 2017—second to natural gas (41%).
- Despite a drop in UPV installations, EIA estimates that DPV grew in 2017 y/y.
- Solar and wind represented approximately 57% of all new sources of generation in 2017, compared to 63% in 2016.

2017 U.S. Generation Capacity Additions (Total 25.6 GW-AC)



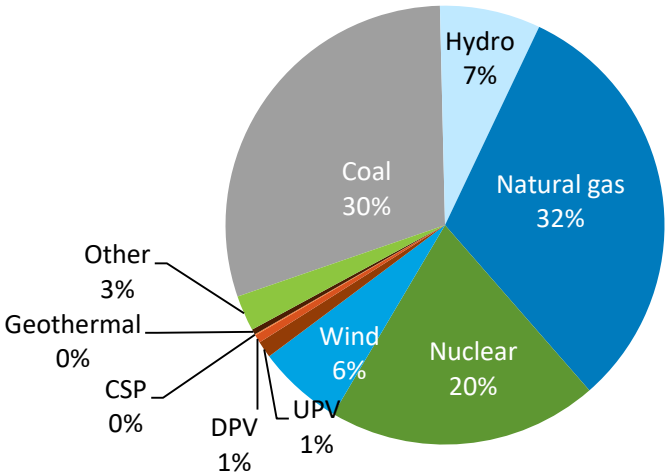
Sources: EIA "Preliminary Monthly Electric Generator Inventory" (December 2017). EIA, "Electric Power Monthly" Table 6.1; 2018. PV data prior to 2015 from GTM Research / SEIA, assuming an ILR of 1.2.

2017 U.S. Generation and Capacity

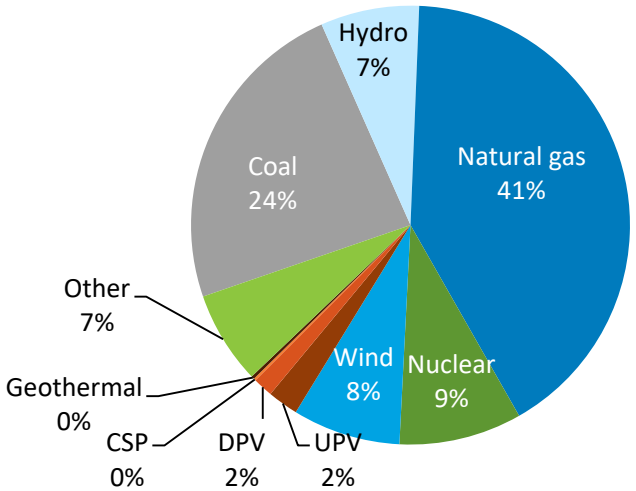
- Despite solar representing a large amount of new generation, it still represents a relatively small amount of total U.S. capacity and generation.
- 62% of U.S. generation came from fossil fuels in 2017 with another 20% coming from nuclear.

- At the end of 2017, solar represented 3.9% of net summer capacity and 1.9% of annual generation.
  - At the end of 2017, all renewables represented 20.6% of net summer capacity and 17.6% of annual generation.
- Capacity is not proportional to generation, as certain technologies (e.g., natural gas) have lower capacity factors than others (e.g., nuclear).

2017 U.S. Generation (Total 4,039 TWh)

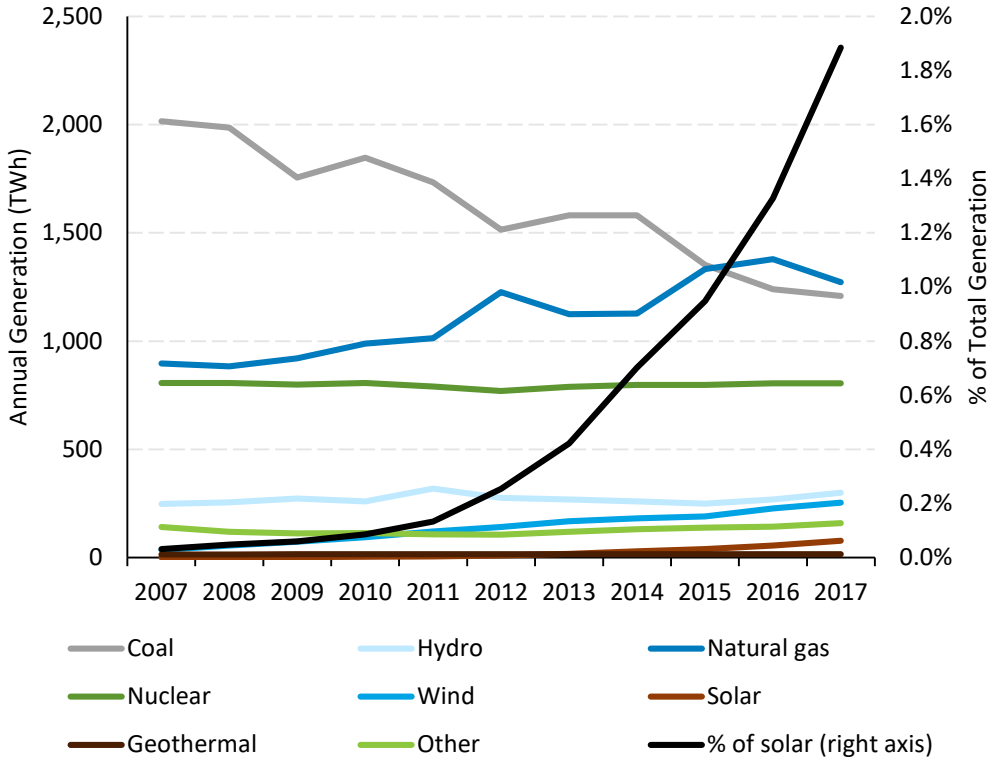


2017 U.S. Generation Capacity (Total 1.1 TW)



Sources: EIA, "Electric Power Monthly" Tables 6.1, 6.2B, 1.1, 1.1A; 2018.

U.S. Generation, 2007-2017



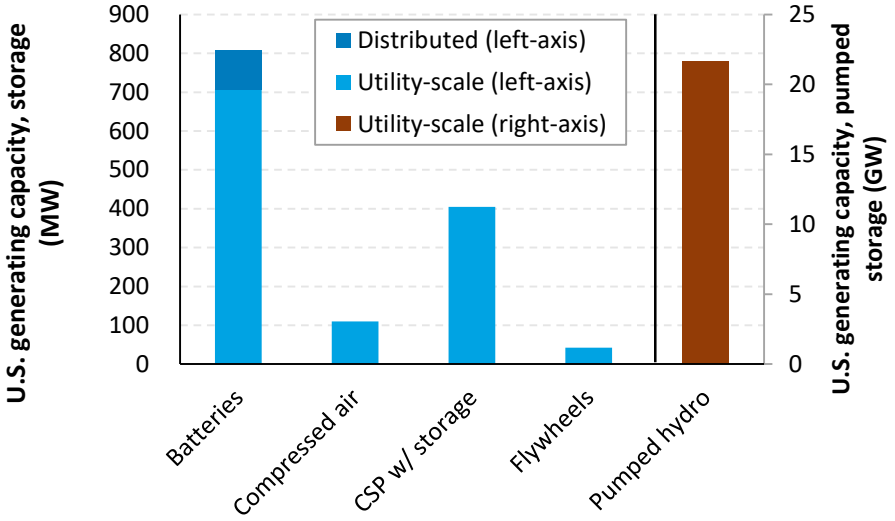
- Coal and natural gas generation have been heading in opposite directions over the past 10 years.
- The percentage of electricity generated by fossil fuels in the United States dropped from 72% to 61% from 2007 to 2017, while over the same period renewable generation increased from 8% to 17%.
- Despite solar only contributing 1.9% of electric generation, its percentage has increased 59X since 2007.

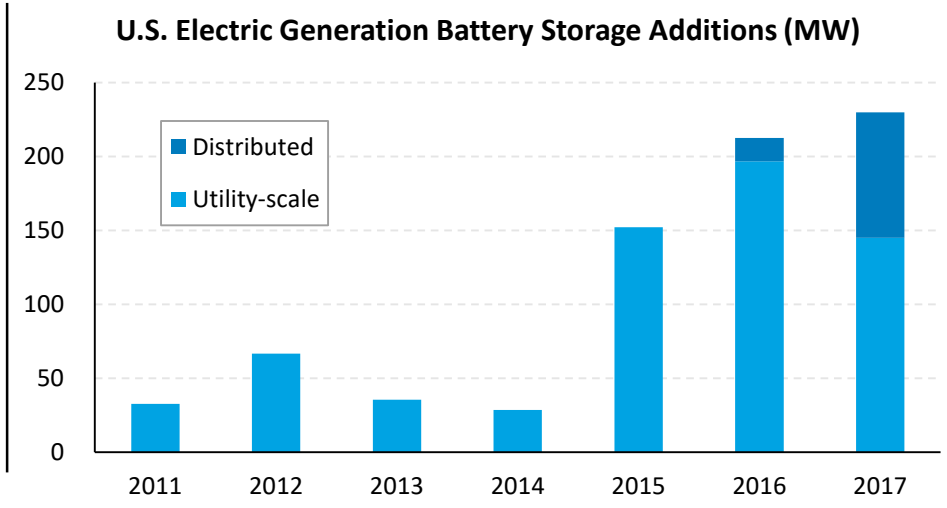
Sources: EIA, "Electric Power Monthly" 1.1, 1.1A; 2018; EIA, "Monthly Energy Review" (2018).

U.S. Storage Capacity Additions by Source

- Pumped hydro continues to be the largest source of energy storage in the United States by an order of magnitude; however, a significant number of batteries have been added to the grid over the past few years due to the rise in renewable capacity and the reduction in battery costs.

- EIA reports that at the end of 2017, the United States had 708 MW of utility-scale electric generation battery storage, up 145 MW from 2016, and 101 MW of distributed storage, up 85 MW from 2016.
- Battery storage still represents a small resource when compared to the 130 GW of PV and wind installed in the United States at the end of 2017.
- New Jersey passed a bill in April 2018 that sets storage targets of 600 MW in 2021 and 2 GW in 2030.



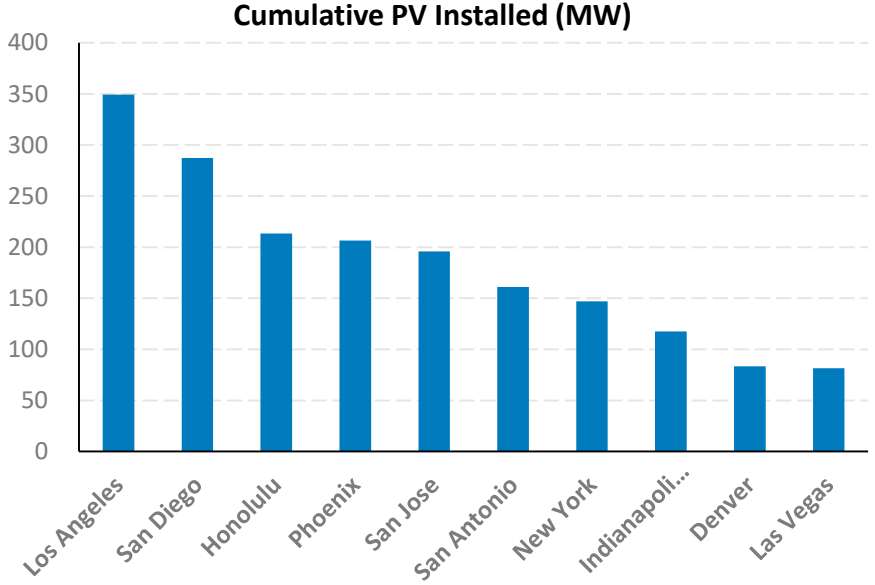


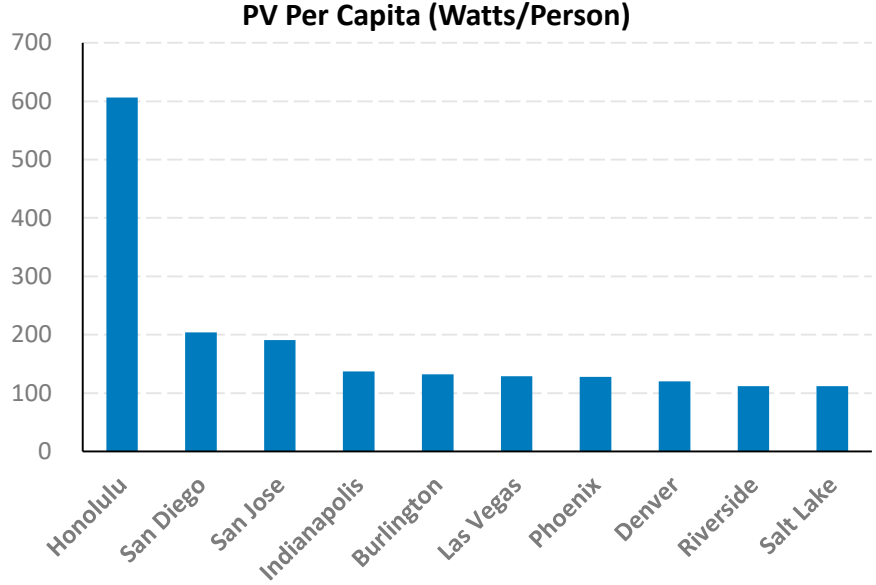
Source: Utility-scale data: EIA "Preliminary Monthly Electric Generator Inventory" (December 2017); distributed data: EIA, form 861M.

Leading U.S. Cities

- At the end of 2017, the top 10 cities represented 1.8 GW of cumulative PV capacity, or 4% of total installed U.S. PV capacity.
- It is estimated that these cities are only using 4%–13% of their technical potential for rooftop installations.

- Twenty cities had installed more than 50 watts/person at the end of 2017.
  - Honolulu had installed approximately three times per capita as the next leading city.



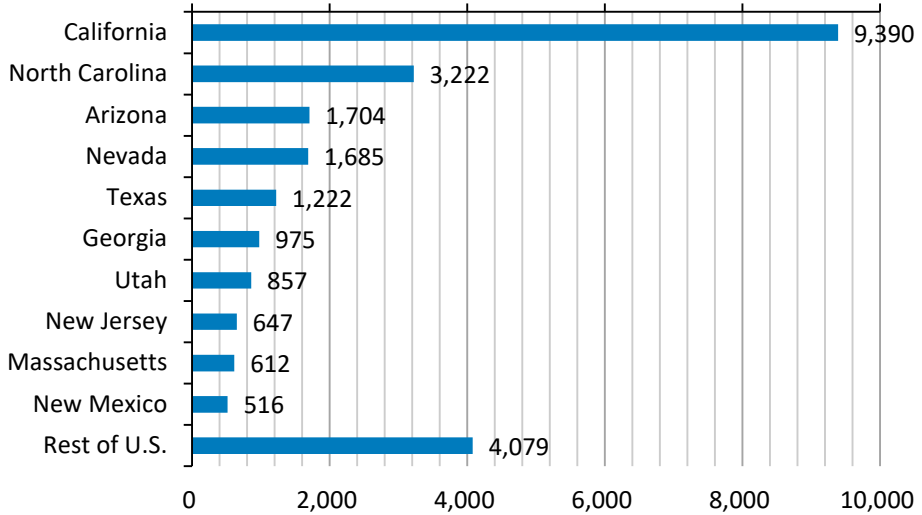


Source: "Shining Cities Harnessing the Benefits of Solar Energy in America." Spring 2018.

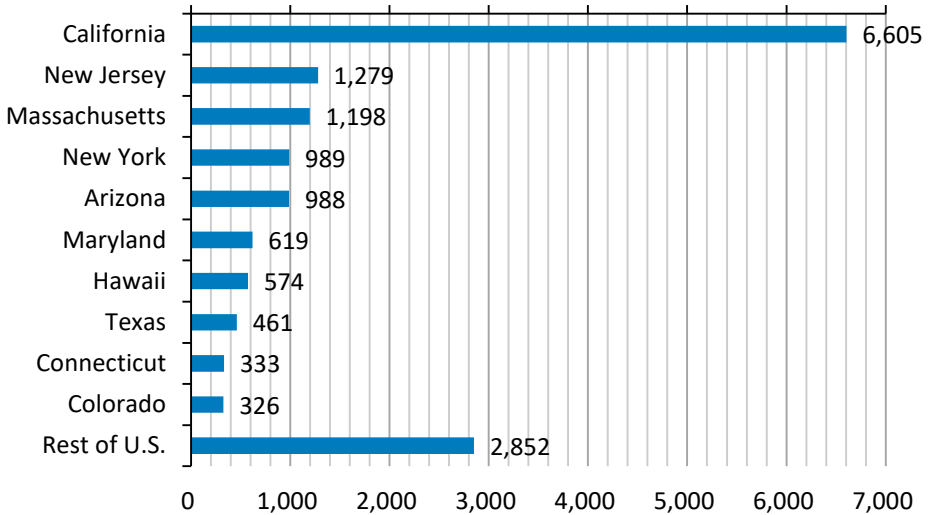
U.S. Installation Breakdown by State

- At the end of 2017, there were 41.1 GW-AC of solar systems in the United States.
- Of the 41.1 GW, 24.9 GW were utility-scale PV and 16.2 GW were distributed PV.
- 16 states had cumulatively installed more than 0.5 GW of PV by the end of 2017.
- At the end of 2017, the top 10 states represented 84% and 82% of UPV and DPV installed capacity, respectively.

UPV Installed Capacity, Top 10 States, as of December 2017
Megawatts (MW-AC)



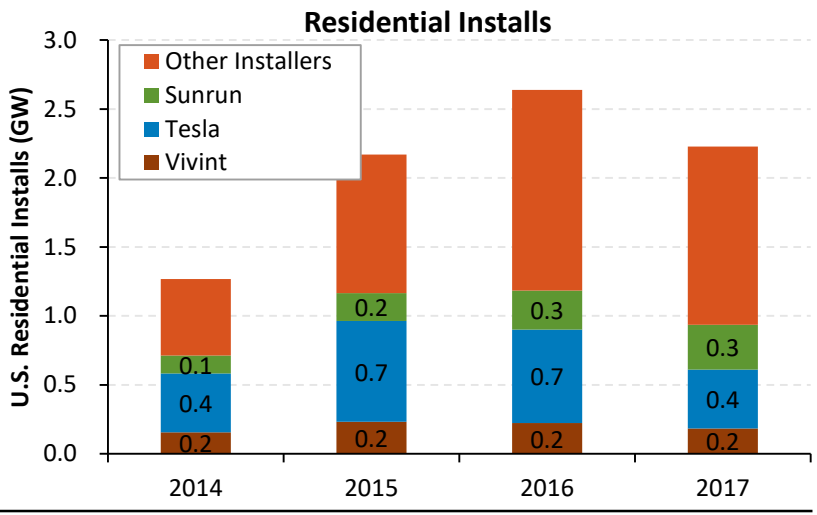
DPV Installed Capacity, Top 10 States, as of December 2017
Megawatts (MW-AC)

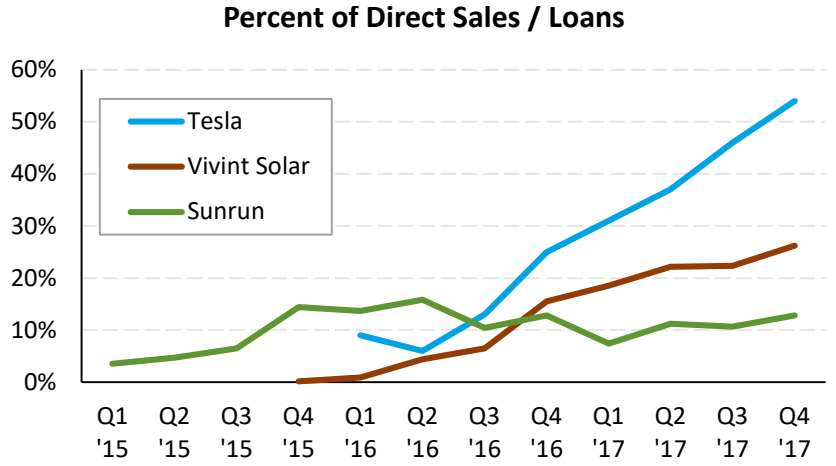


Note: EIA monthly data for 2017 are not final. Additionally, smaller utilities report information to EIA on a yearly basis, and therefore, a certain amount of solar data has not yet been reported. "Net Generation" includes DPV generation.
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (January 2017).

Tesla, Vivint Solar, and Sunrun Residential Market Share

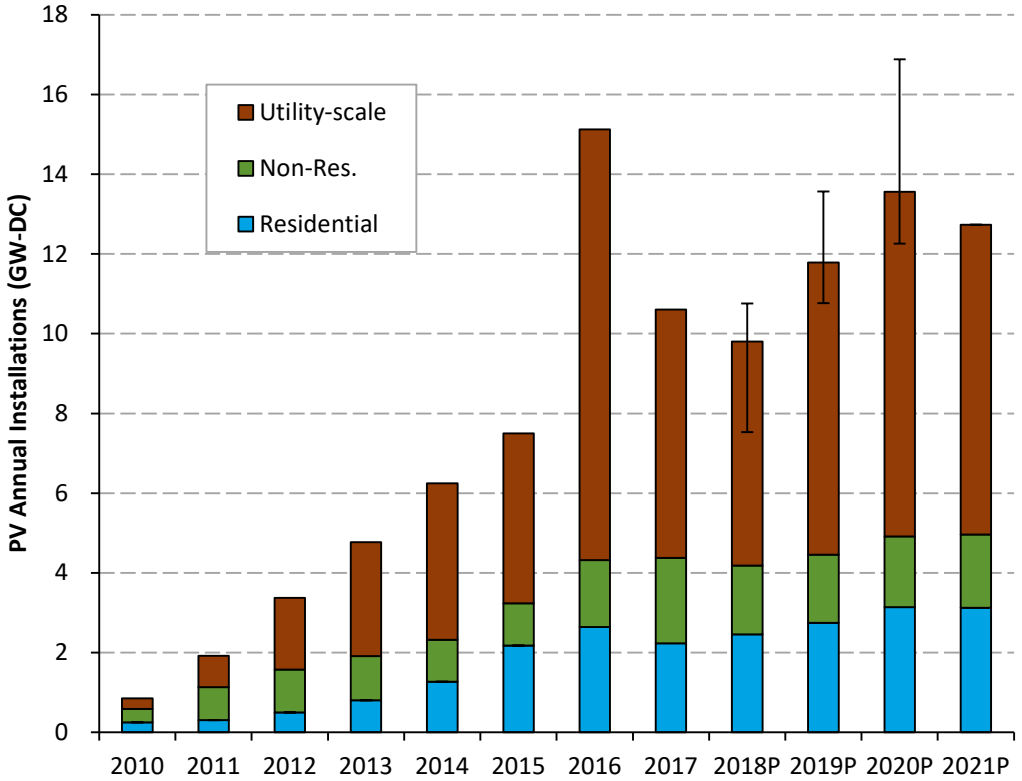
- The U.S. residential PV market contracted 16% in 2017, in part due to lower volume by national installers.
- While many national installers contracted, Sunrun annual deployment grew 15% in 2017.
  - In H2 2017, Sunrun became the largest U.S. residential installer.
- Direct sales continue to grow residential PV market share.
  - In Q4 2017, direct sales represented 54% of deployments from Tesla, historically the largest TPO provider.
- Tesla and Sunrun are also expanding product offerings through PV+storage.
  - Tesla installed 410 MWh of storage in 2017 globally.
  - 20% of Sunrun's California customers opted for their solar+storage option; the company also launched its storage option in Hawaii, Arizona, Nevada, New York, and Massachusetts.





Source: Corporate filing, GTM/SEIA Solar Market Insight Q4 2017; Greentech Media (March 12, 2018).

Annual U.S. PV Demand Projections

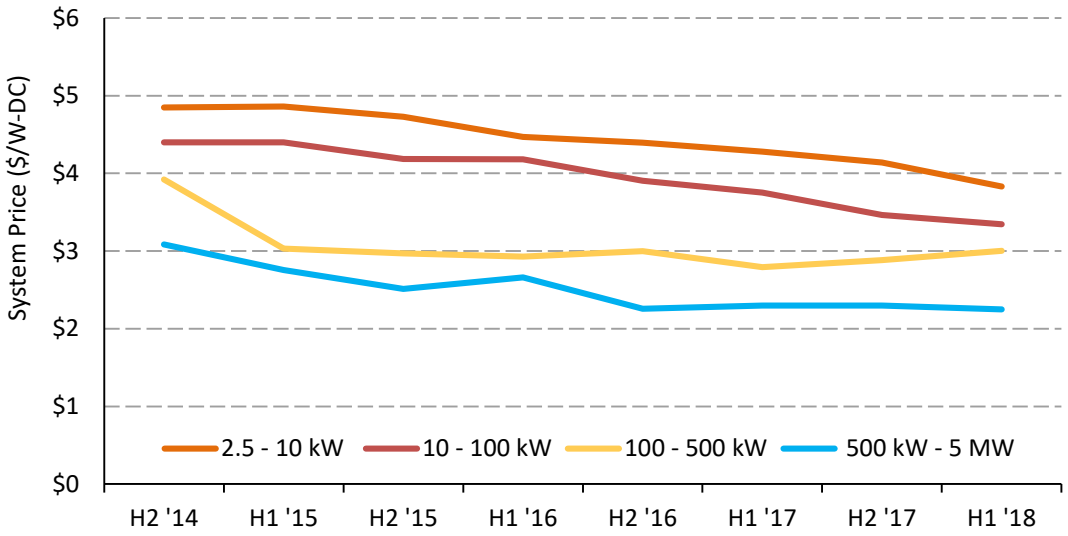


- Analysts estimate U.S. solar installations in 2018 will be between 7.5 GW and 10.8 GW, with most analysts expecting further market contraction.
  - The drop in deployment is expected to come mostly from the utility-scale sector, with only the residential sector expanding.
  - Market contraction in 2017 and 2018 has been attributed to: the Section 201 tariffs on PV modules; pipeline depletion caused by the 2016 rush to obtain a 30% tax credit (which was later extended through 2019); a lull in deployment before the 2019 rush to obtain the full federal tax credit before it begins declining in 2020; and the slowing of growth in the top U.S. markets.
- The median analyst projection predicts that 48 GW of PV will be installed between 2018 and 2021– approximately the same amount installed at the end of 2017.

Note: P = projection. Bar represents median projection. Error bars represent high and low projections.
Sources: BNEF (April 2018); Deutsche Bank (01/05/18); Goldman Sachs (01/09/18); GTM Research (March 2018).

- **From H2 2016 to H2 2017, EnergySage reported a 7% reduction in the average gross costs of a residential system, to $3.13/W.**
- **In Q4 2017, totals costs for Vivint- and Sunrun-built systems were between $2.65/W to $3.00/W.**
- **In a select data set of utility-scale PV systems, the median system price in 2017 was $2.16/W-AC ($1.66/W-DC).**

System Pricing From Select States



Based on preliminary data for H1 2018, from H1 2017 to H1 2018, the median reported PV system price in the four states analyzed:

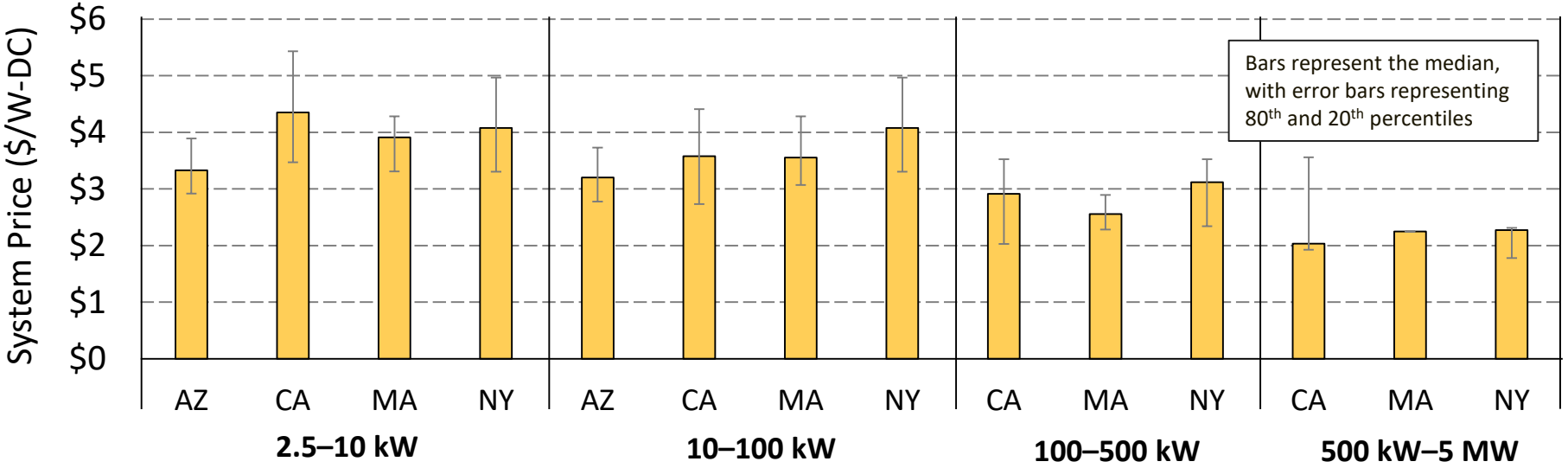
- Fell 10% to $3.83/W, for systems 2.5 kW–10 kW
- Fell 11% to $3.34/W, for systems 10 kW–100 kW
- Increased 8% to $3.00/W, for systems 100 kW–500 kW
- Fell 2% to $2.25/W, for systems 500 kW–5 MW.

Preliminary H1 2018 MW: AZ (48), CA (47), MA (13), NY (72)
Note: California pricing data before 2015 are collected from the California Solar Initiative database. CA NEM data have only been reported through November 2017.
Sources: CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; NY PV Incentive Program. All programs accessed 01/17/2018.

System Pricing From Select States, H1 2018

- In addition to price differences based on system size, there is also variation between states and within individual markets.

- Based on initial data in H1 2018, the median price of a small system in Arizona was about 23% less than the median price in California.
- In H1 2018, the 20th and 80th percentile prices in California for a small system were $3.47/W and $5.43/W, respectively.



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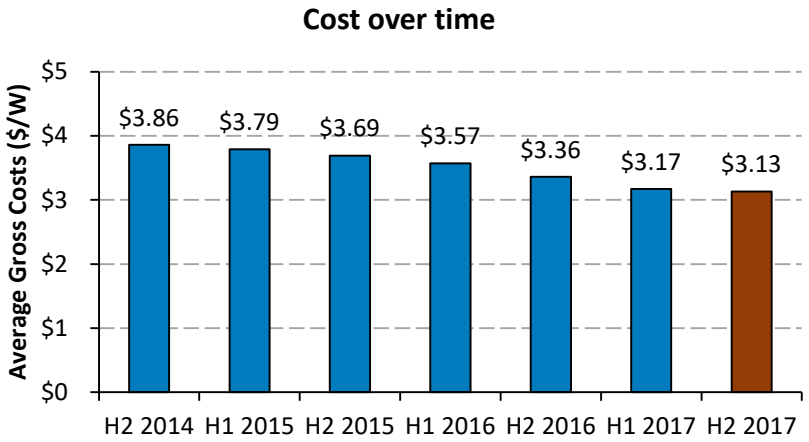
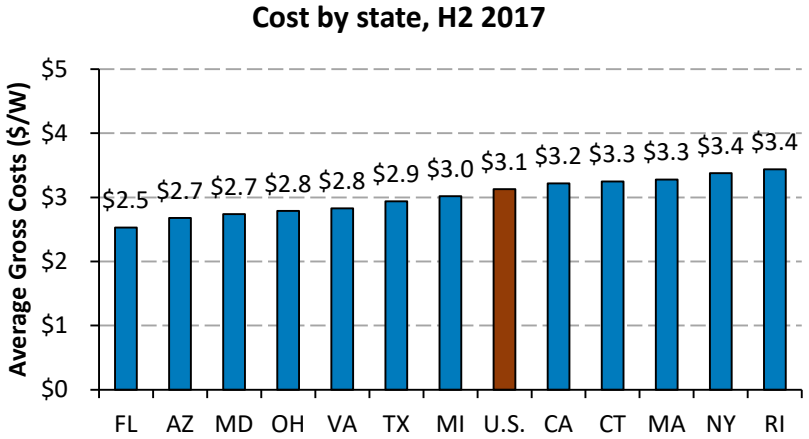
Sources: CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; NY PV Incentive Program. All programs accessed 01/17/2018.

System Costs Reported by EnergySage

- From H2 2016 to H2 2017, EnergySage reported a 7% reduction in the average gross costs of a residential system.
- EnergySage quotes also reported an average system payback period of 7.4 years.
- Residential system quotes varied by state. In H2 2017, the average gross cost of a residential system in Rhode Island was 36% higher than the average gross cost of a residential system in Florida.



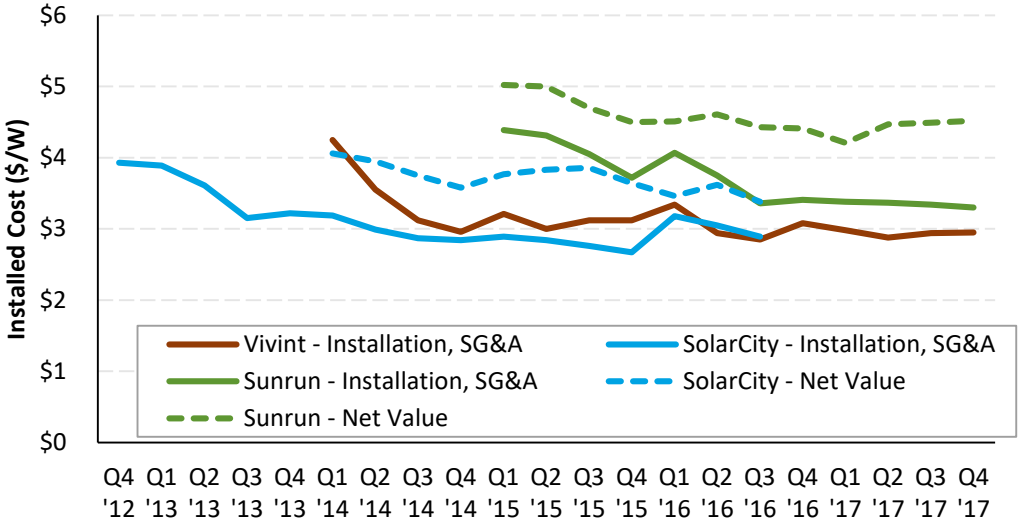


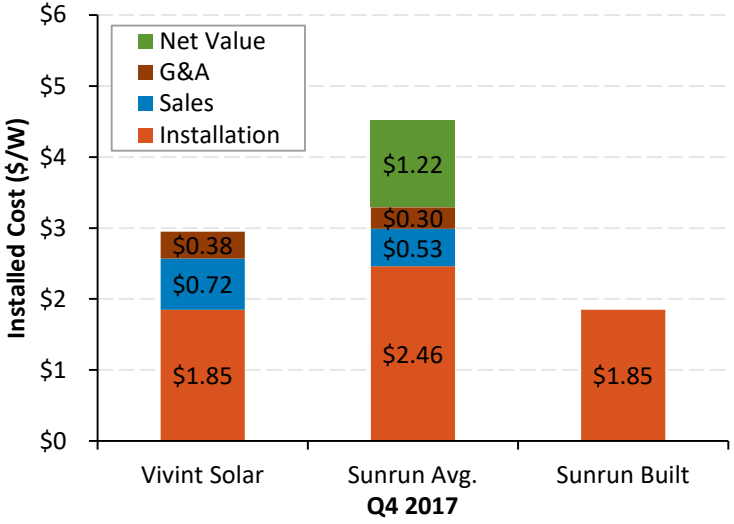
Source: EnergySage, "Solar Market place Intel Report H1 2017 – H2 2017."

Vivint Solar, Sunrun, and SolarCity Cost and Value

- From Q4 2016 to Q4 2017, Vivint Solar and Sunrun total system costs remained relatively flat, falling 4% and 3%, respectively.
  - Vivint Solar- and Sunrun-built installation costs decreased 10% and 9% y/y, respectively, to $1.85/W.

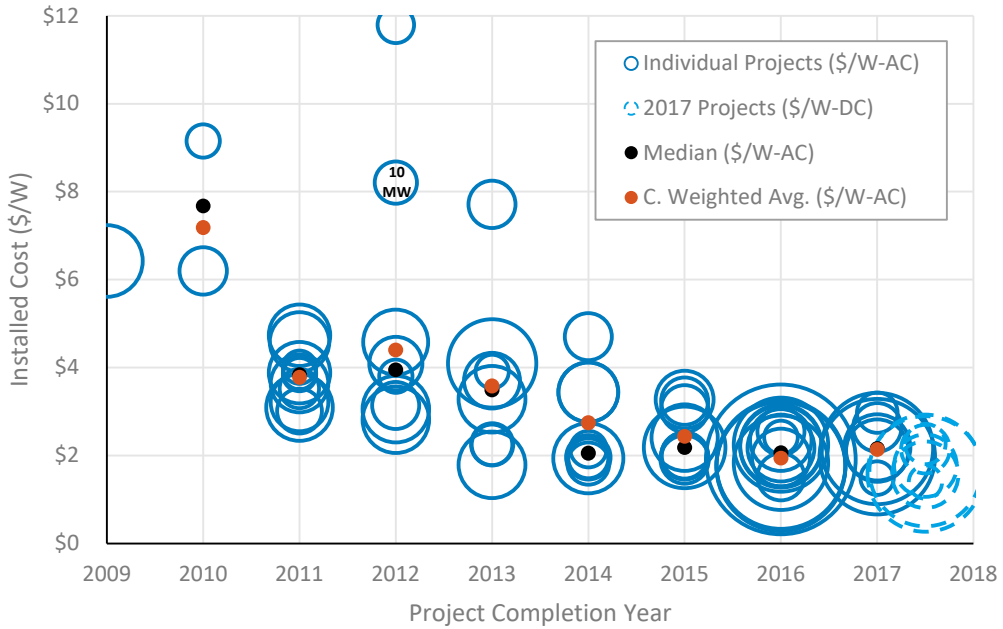
- In Q4 2017, totals costs for Vivint- and Sunrun-built systems were between $2.65/W and $3.00/W.
- Sunrun still reports a PV system net value of approximately $4.5/W .





Sources: Corporate filings

Utility-Owned PV Pricing (>5 MW)



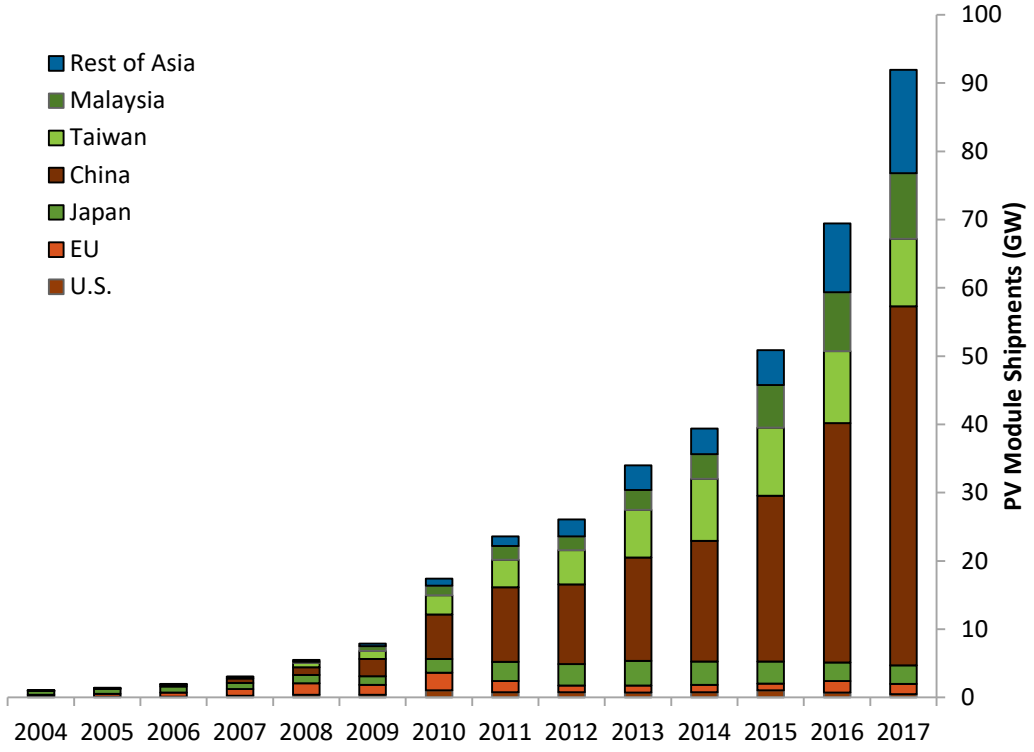
# of systems	2	11	8	8	8	9	14	7
MW-AC	15	131	101	120	94	125	541	176

- In a select data set of utility-scale PV systems (68 projects totaling 1.4 GW-AC) from 15 regulated utilities, the median system price in 2017 was $2.16/W-AC ($1.66/W-DC).
- The median price is similar to the median system price reported from 2014 to 2016; however, the capacity-weighted average is approximately 28% lower than the capacity-weighted average from 2014.
- Several reasons may explain the lack of price reduction over the past few years:
  - Many of the systems installed in 2017 occurred in the first part of the year and, therefore, may have "spilled over" from 2016.
  - PV systems with one-axis tracking continue to gain market share, which lowers the cost of energy but increases upfront installation costs.
  - PV systems have been built with higher ILRs and, therefore, the same capacity of inverters may be associated with a larger capacity of inverters.
  - Project completion year is less correlated to PV system price than contract signing year.
  - While representing over 1 GW of PV systems, this data set still represents a relatively small amount of the 25 GW of U.S. utility-scale PV systems installed at the end of 2017.

Sources: FERC Form 1 filings from the from the following utilities: Alabama Power, Allete, Arizona Public Service, Duke Energy, Flower Power and Light, Georgia Power, Indiana Michigan Power, Nevada Power, Pacific Gas and Electric, Public Service of New Mexico, Southern California Edison, Tucson Electric, United Illuminating, UNS Electric, Virginia Electric.

- **Global PV shipments in 2017, which were mostly from Asia, were approximately 92 GW—an increase of 32% from 2016.**
- **Gross margins remained relatively flat; however, operating margins fell in 2017.**
- **In 2017, the United States produced approximately 260 MW of PV cells and 970 MW of PV modules—a decrease of 66% and 43%, respectively, year over year.**

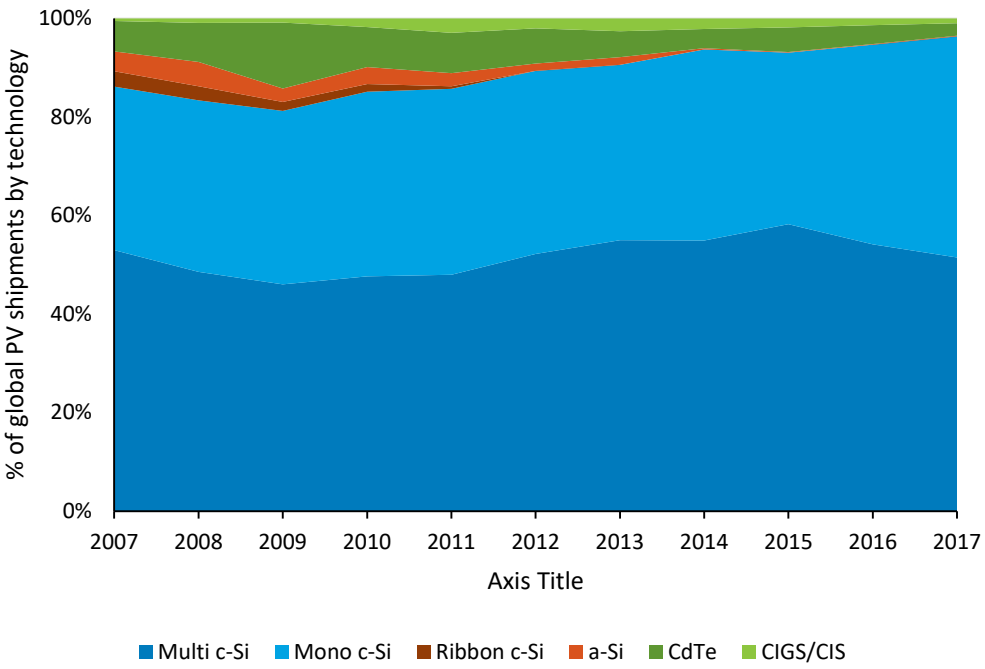
Global Annual PV Shipments by Region*



- In 2017, global PV shipments were approximately 92 GW—an increase of 32% from 2016.
  - 98% of the PV shipments came from Asian countries, with China supplying 57%.
    - China and Taiwan are even more dominant in global c-Si wafer shipments.
- From 2004 to 2017 the compounded average growth rate of global PV shipments was 41%, with growth coming mostly from Asia.
  - In 2005, Japan, the United States, and Europe shipped 92% of global PV modules, falling to 5% in 2017.
  - The United States supplied approximately 0.5% of global PV modules in 2017.

***Note:** Excludes inventory sales and outsourcing.
Source: 2007-2017: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2017/2018." SPV Market Research. Report SPV-Supply6. April 2018.

Global Annual PV Shipments by Technology*



- Technologies have gained and lost market share over time as companies and researchers push forward new PV technologies.
- Mono c-Si, which had a global PV market share of approximately 90% in 1981, grew its global market share from 35% in 2015 to 45% in 2017 as companies ramped p-type PERC manufacturing.
  - GCL-Poly and LONGi announced in early 2018 that by the end of the decade they would increase their mono c-Si manufacturing capacity to 20 GW of ingots and 45 GW of wafers, respectively.
- Thin-film technologies continue to lose market share, falling to 4% in 2017.
  - Thin-film technologies peaked in the 1980s due to the consumer indoor market (e.g., calculators) and again in 2009 during a period of silicon shortage.

***Note:** Excludes inventory sales and outsourcing.
Sources: 2007-2017: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2017/2018." SPV Market Research. Report SPV-Supply6. April 2018. PVTech (April 2018).

Global Leading PV Manufacturers, by Shipments

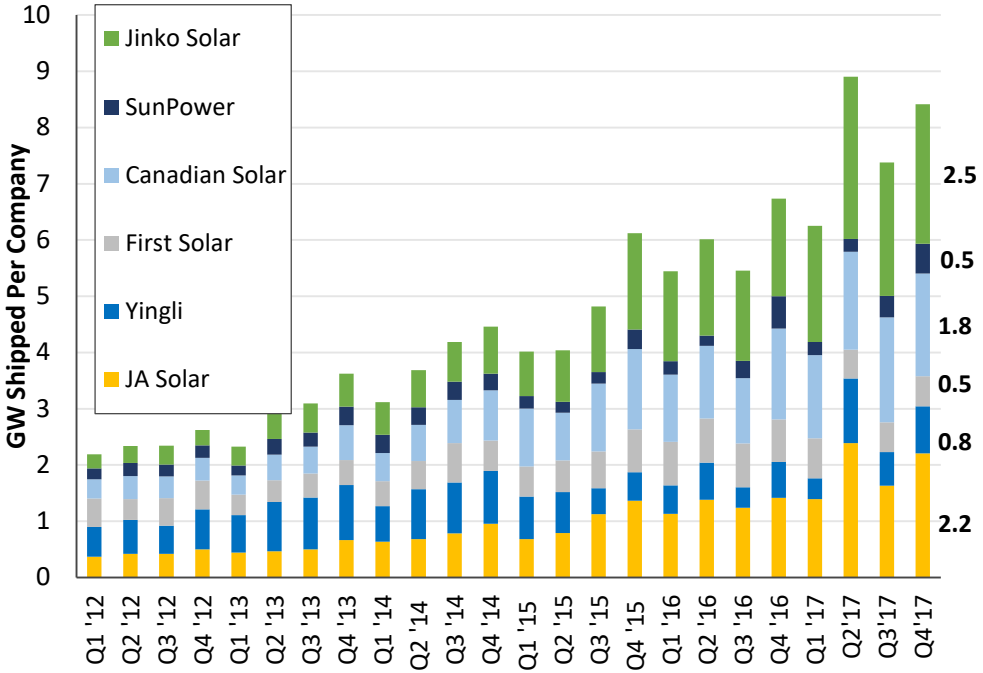
Rank	Manufacturer (2017)	Shipments (GW)	Manufacturer (2016)	Shipments (GW)	Manufacturer (2007)	Shipments (GW)
1	**JA Solar**	**6.5**	Trina	5.0	Sharp	0.4
2	**Canadian Solar**	**5.4**	JA Solar	4.9	Q-Cells	0.3
3	**Zhongli Talesun**	**5.0**	Hanwha	4.0	Suntech	0.3
4	**Jinko Solar**	**4.9**	Jinko Solar	3.9	Kyocera	0.2
5	**Trina Solar**	**4.8**	Motech	2.9	First Solar	0.2
6	**LONGi**	**4.5**	First Solar	2.7	Motech	0.2
7	**Hanwha**	**4.2**	Longi Lerri	2.7	Sanyo	0.2
8	**Tongwei**	**3.8**	Canadian Solar	2.4	SolarWorld	0.1
9	**Motech**	**3.2**	Yingli	2.4	Mitsubishi	0.1
10	**Aiko**	**3.1**	Shunfeng-Suntech	2.2	SunPower	0.1
Other		**45.5**		36.4		1.0
Total		**91.9**		69.5		3.0

- In 2007, there was significant geographic diversity of manufacturers.
- Since then, Asian manufacturers have significantly scaled operations; however, many of the leading manufacturers in 2017 have scaled-up faster than many of the top Asian manufacturers from a few years ago.
- 2017 marks the first time since 2006 that First Solar did not break the top 10 in PV shipments.
- Each of the top 10 PV manufacturers shipped more in 2017 than the entire industry did in 2007.

***Note:** Excludes inventory sales and outsourcing.
Source: 2007-2017: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2017/2018." SPV Market Research. Report SPV-Supply6. April 2018.

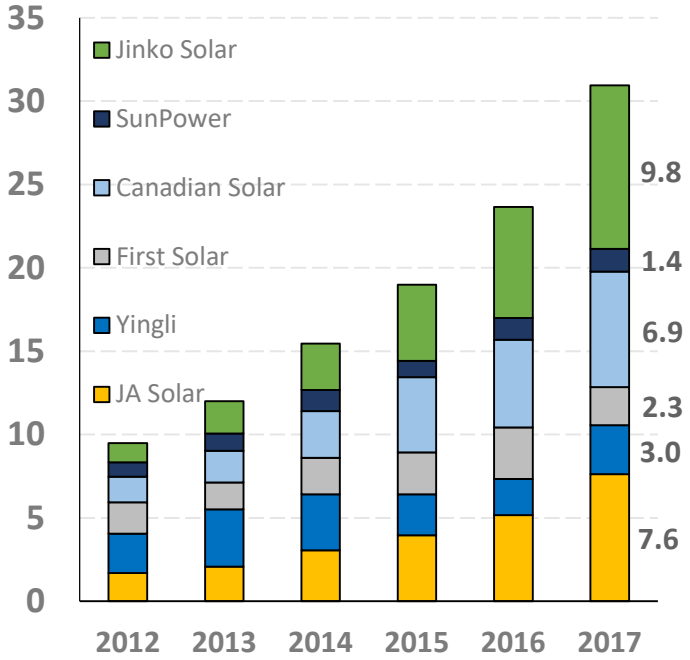
Manufacturers' Shipments

Publically Traded Cell/Module Manufacturers

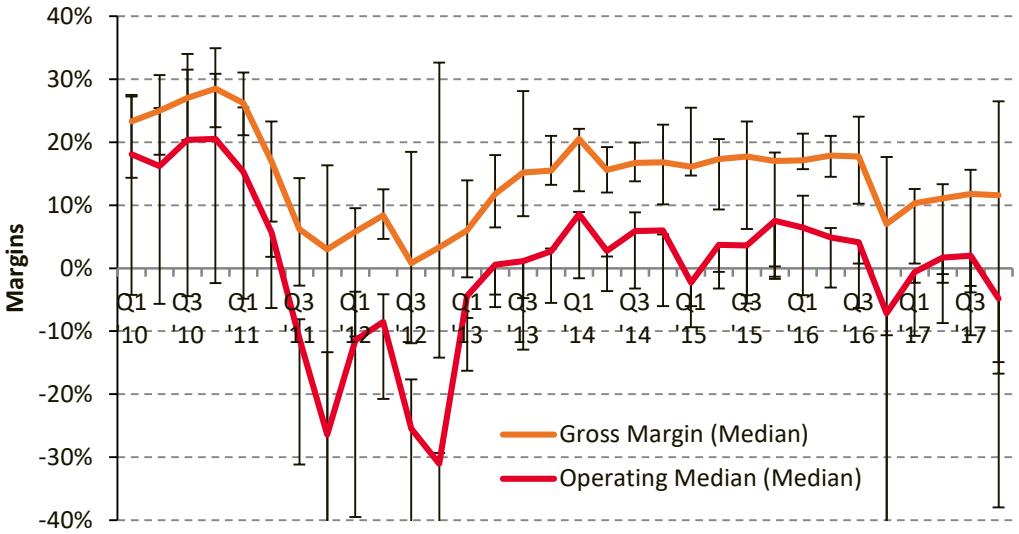


Notes: First Solar reports data on production, not shipments.
Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies.

- In 2017, the tracked companies shipped 31 GW, an increase of 24% over 2016.
- Q2 shipments were greater than Q4 shipments due to the reduction in Chinese FiT rates in H2.



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, SunPower, and Yingli Solar.

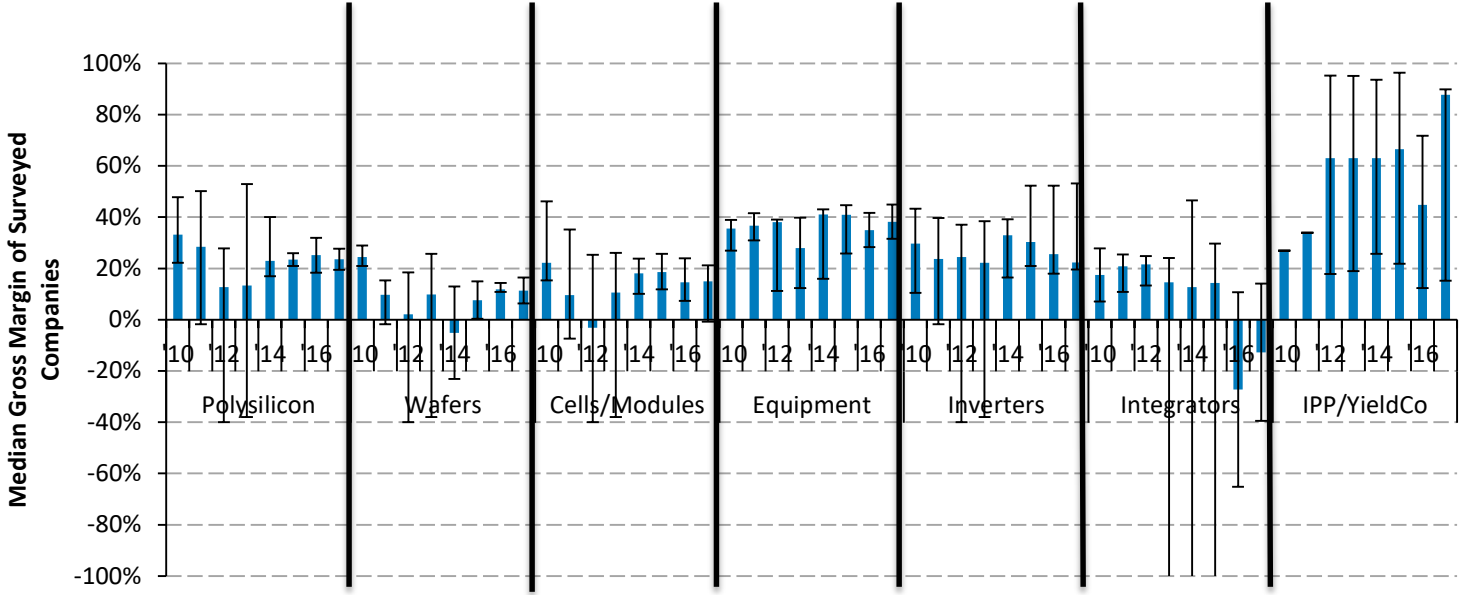
- The tracked companies had almost no change in median gross margin in 2017. However, there was a sharp fall in the median operating margin, from 2% in Q3 2017 to -5% in Q4 2017.
  - The lower operating margin was not necessarily systemic as the companies with lower margins reported: a lower reported quarterly sales due to project delays (First Solar), a one-time bad debt expense (Hanwha), and a one-time impairment charge of residential lease assets (SunPower)

Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies.

Gross Margin Across Supply Chain

- YieldCos continue to get higher margins than other sectors of the supply chain, with wide variance among individual Yieldcos, which had gross margins ranging from 15% to 90% in 2017.

- There was a significant increase in average gross margins for YieldCos and Integrators in 2017. In other sectors there were only small changes compared with 2016.

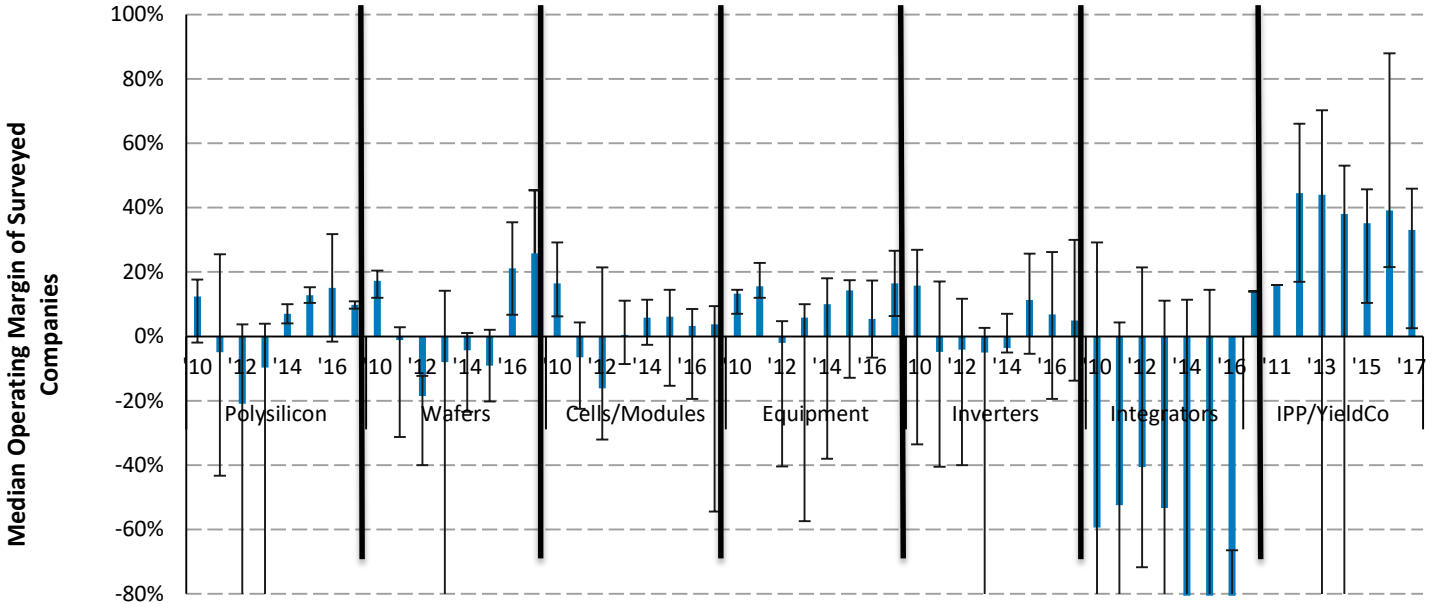


Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies. Error bars represent high and low values of surveyed companies. Companies surveyed are: Wafers - LDK Solar, ReneSola, SAS Wafers, Wafer Works Corp., Solargiga; Poly - GCL-Poly, REC Silicon, Wacker, LDK Solar; Cells/Modules, Gintech, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian, PV Crystalox Solar ,Hanwha SolarOne, Jinko Solar, SunPower, LDK Solar; Integrators - Real Goods Solar, SolarCity, Vivint, SunEdison; Inverters - Power-One, SMA, Satcon, Enphase Energy, Advanced Energy Industries; IPP/Yieldco - Abengoa Yield, NRG Yield, NextEra Energy Partners, Northland Power Inc., Pattern Energy, Terraform Power, Sky Solar Holdings.

Operating Margin Across Supply Chain

- Operating margin is not necessarily an indicator of corporate profitability, though with strong margins companies should eventually figure a way to profitability.

- There was a wide variation in operating margins in 2017 as companies tried to gain market share and pursue new strategies.
  - There was substantial variation across the supply chain as integrators sacrifice short-term profits to scale rapidly.

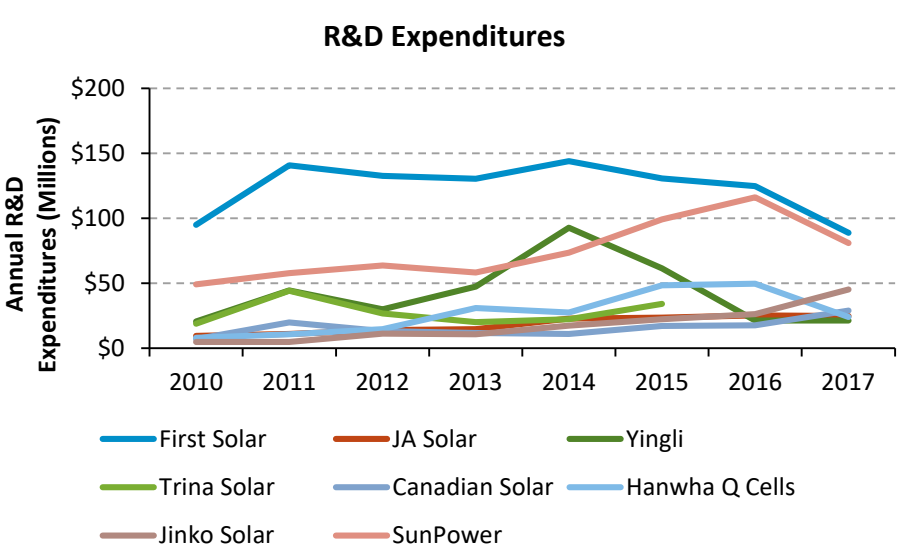


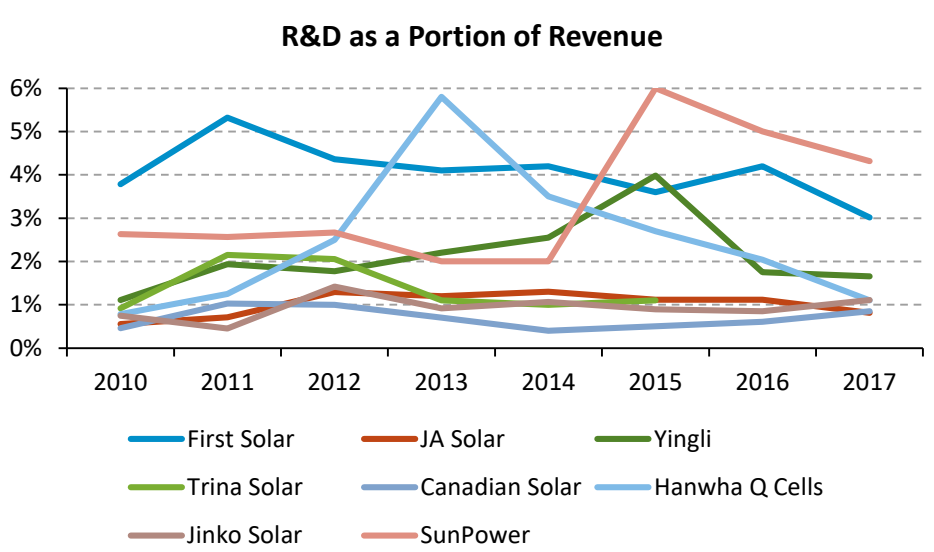
Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies. Error bars represent high and low values of surveyed companies. Companies surveyed are: Wafers - LDK Solar, ReneSola, SAS Wafers, Wafer Works Corp., Solargiga; Poly - GCL-Poly, REC Silicon, Wacker, LDK Solar; Cells/Modules, Gintech, Motech, First Solar, JA Solar, Yingli, Trina Solar, Canadian, PV Crystalox Solar ,Hanwha SolarOne, Jinko Solar, SunPower, LDK Solar; Integrators - Real Goods Solar, SolarCity, Vivint, SunEdison; Inverters - Power-One, SMA, Satcon, Enphase Energy, Advanced Energy Industries; IPP/Yieldco - Abengoa Yield, NRG Yield, NextEra Energy Partners, Northland Power Inc., Pattern Energy, Terraform Power, Sky Solar Holdings.

Research and Development

- R&D among the tracked companies fell significantly to $313 million in 2017 from $380 million in 2016, a fall of 18% y/y.

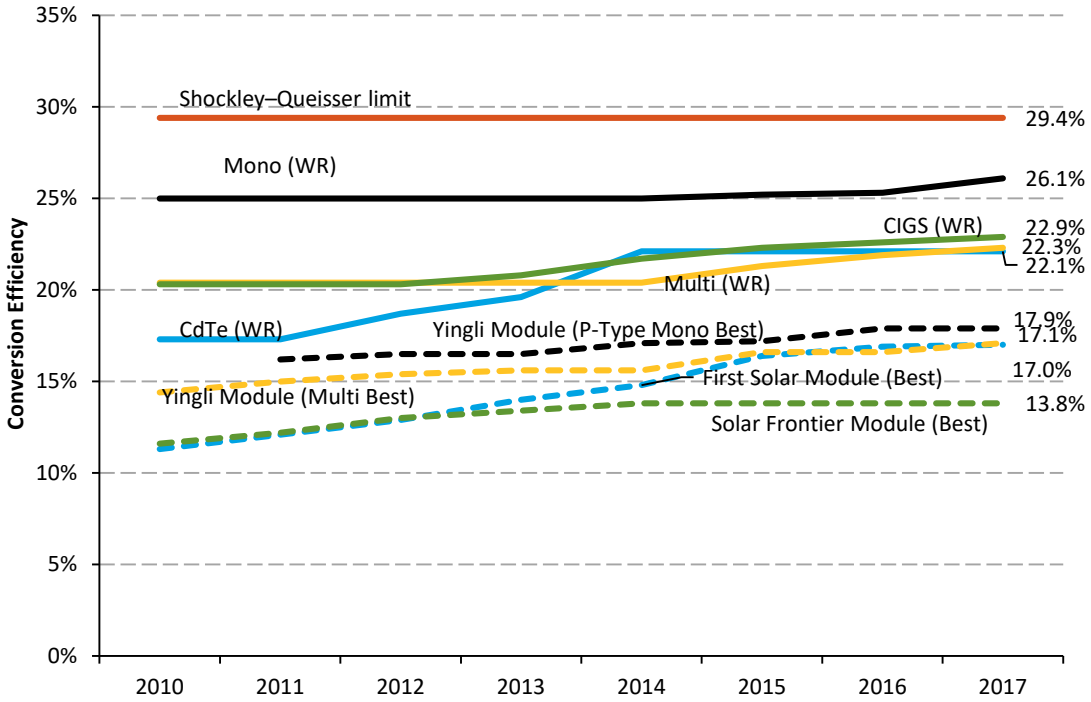
- First Solar continues to lead in R&D spending, although SunPower is a close second. Both companies cut R&D funding significantly in 2017.
- In past years, Canadian Solar and Jinko Solar have had relatively small R&D budgets but increased R&D spending this year by 65% and 73%, respectively.





Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies.

PV Efficiency Improvements

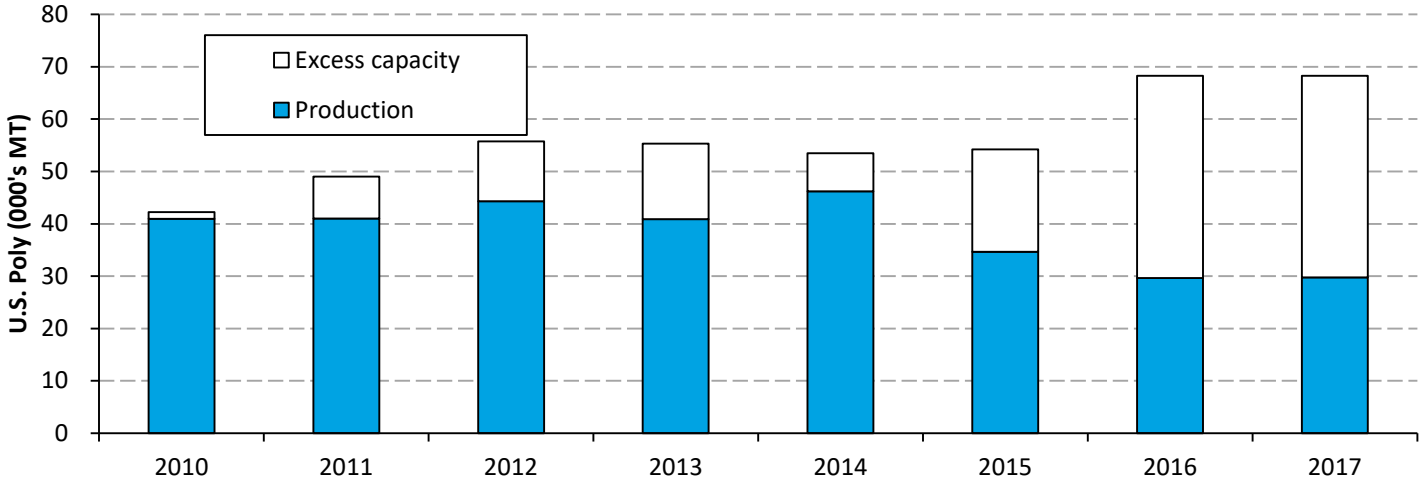


- Mono c-Si, multi c-Si, and CIGS all achieved world records in the lab in 2017.
  - Despite Solar Frontier's world record achievement for CIGS, the company continues to sell modules well below the efficiency of other products.
- CdTe now has virtually the same module efficiency as multi in the marketplace.
  - Standard p-type mono modules still have a ~1% efficiency advantage over multi and CdTe.

Note: WR denotes "World Record."
Sources: Corporate press releases and public filings, NREL World Records.

U.S. Polysilicon Manufacturing

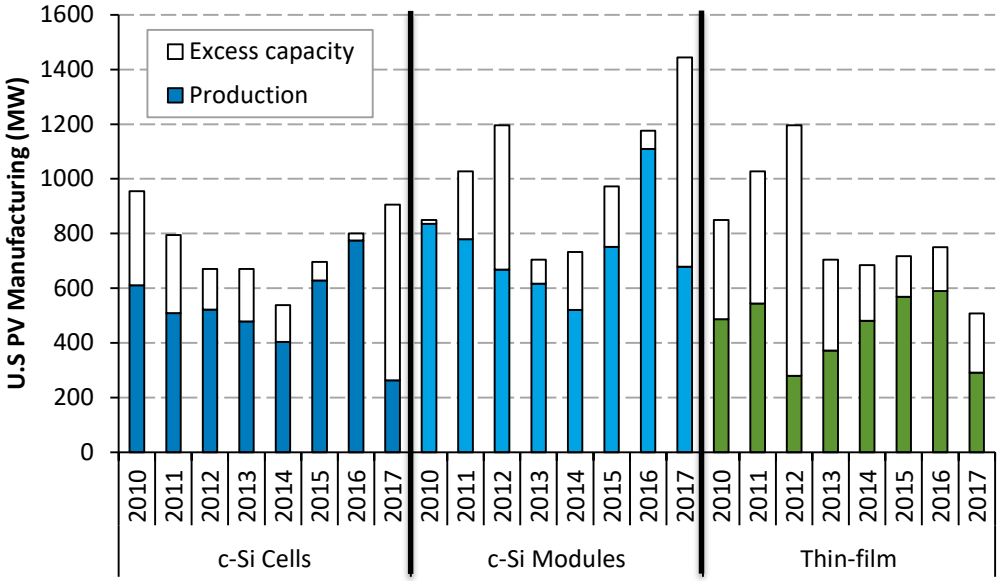
- From 2010 to 2014, U.S. polysilicon production was relatively flat; however, China's antidumping tariffs, which were effectively implemented in August 2014, appear to have reduced U.S. polysilicon manufacturing by approximately 25%.
- Poly utilization rate was down from 86% in 2014 to 43% in 2016 and 2017.



Source: GTM Research & SEIA, "U.S. Solar Market Insight: Year-in-Review" (2011-2018).

U.S. Module and Cell Manufacturing

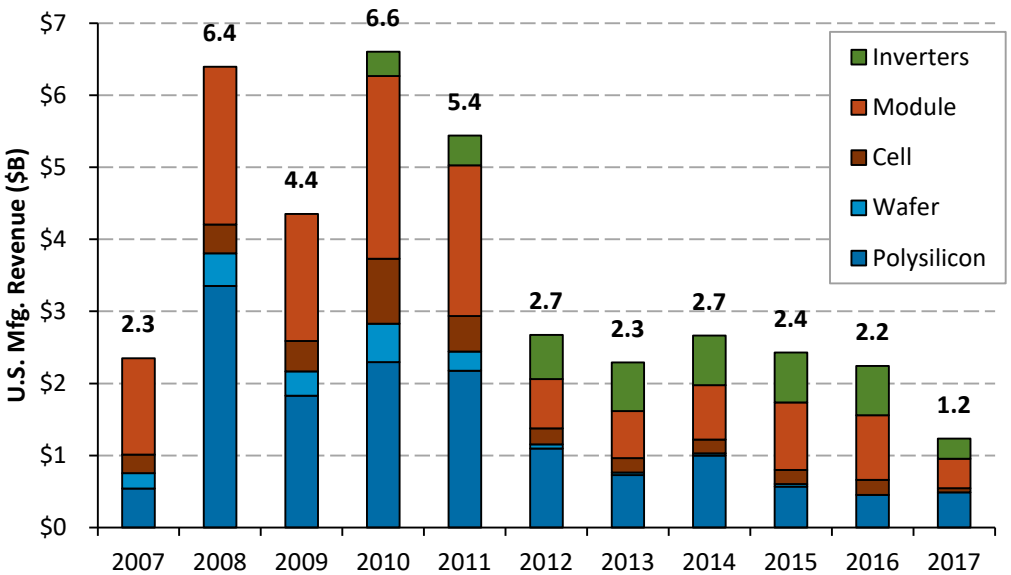
- Due to an increased competitive landscape, U.S. manufacturers closed down production lines to switch to more advanced designs (e.g., First Solar) or caused by bankruptcies (e.g., Suniva, SolarWorld).



Source: GTM Research & SEIA, "U.S. Solar Market Insight: Year-in-Review" (2011-2018).

- In 2017, the United States produced approximately 260 MW of PV cells and 970 MW of PV modules—a decrease of 66% and 43%, respectively, year over year.
  - U.S.-produced c-Si cells represented 39% of U.S.-produced c-Si modules in 2017.
  - U.S.-produced PV modules represented 9% of annual U.S. PV installations in 2017.
- U.S. c-Si cell, c-Si module, and thin-film module manufacturing had utilization rates of 29%, 47%, and 57% in 2017, respectively. With the implementation of tariffs on imported PV modules in the beginning of 2018, and First Solar's Series 6 production ramp-up, the United States has the potential to produce significantly more PV modules and cells in 2018.
- There is approximately 0.5 GW more U.S. c-Si module assembly than cell assembly; if module assembly producers used U.S. cells, an additional 2 GW of manufacturing capacity could be built before hitting the 2.5-GW import exemptions of PV cells.

Estimated U.S. PV Manufacturing Revenue

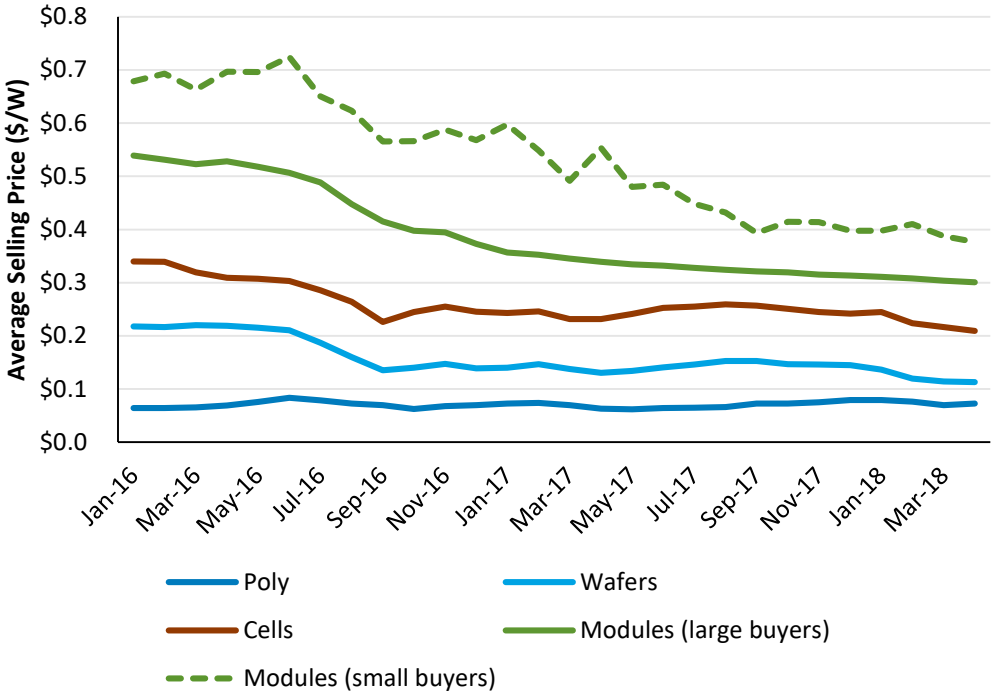


- In 2017, U.S. manufacturers of polysilicon, cell, module, and inverters had estimated revenues of approximately $1.2B, $1B less than in 2016 and $5.4B less than their peak in 2010.
  - The largest decrease in revenues, year-on-year, came from the U.S. PV cell sector, dropping ~75%, followed by U.S.-produced inverters, which shipped 55% fewer inverter capacity in 2017 than in 2016; revenues from U.S.-produced polysilicon was flat.
- These values do not incorporate all revenues from companies that manufacture PV products in the United States; other parts of the U.S. PV supply chain include racking, encapsulants, and backsheets.

Note: measured by U.S. production x average component price.
Source: production of wafer/cell/module 2007-15: GTM "Wafer Cell Module Database". February 2017. Polysilicon 2007-11: IEA, U.S. NSR, 2007-2011. Wafer/cell/module/poly 2016-17 (production) : GTM/SEIA “U.S. Solar Market Year-in-Review” (2017, 2018). Price, 2007-11: Photon Consulting, "Solar Annual 2012" & "Solar Annual 2009“; 2012-2017 (price): GTM/SEIA “U.S. Solar Market Insight Year-in-Review” (2013-2018).

- **Global module ASP continues to decline to a low 30 cents/W, while many manufacturers report module costs at similar values.**
- **Recent analyst reports indicate global module prices and costs are expected to continue to drop in the next few years.**
- **U.S. module pricing traded at a premium in late 2017 due to tariff concerns.**
- **String and central inverter pricing were flat while MLPE prices and costs continue to drop.**

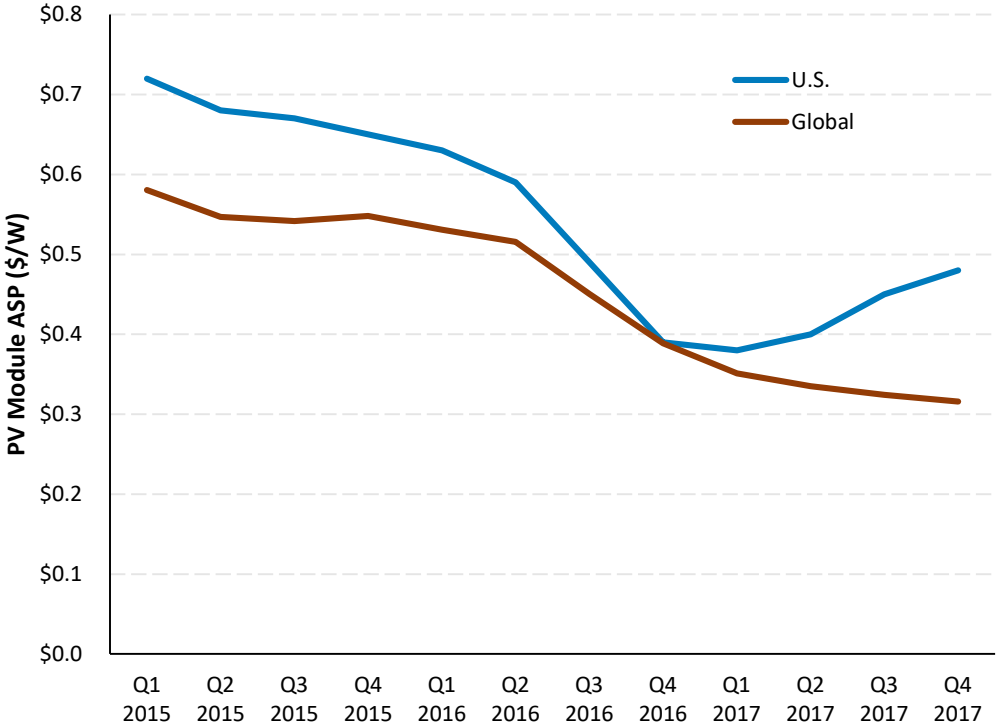
PV Value Chain Spot Pricing



- BNEF reported a slow in price drop across the value chain in March 2018 due to anticipation of an active Q2 in China.
- Wafer prices fell the most in the first quarter of 2018 due to strong competition, followed by cells and polysilicon.
- BNEF also reported that Chinese manufacturers had a low shipment-to-capacity ratio in the first 2 months of 2018.

Sources. "Modules (large buyers)" from PVInsights, accessed 01/17/18. Remaining pricing data from BNEF Solar Spot Price Index (04/24/18). Kilogram to Watt conversion: 4.78 grams per watt (2016); 4.73 grams per watt (2017, 2018), from Cowen & Co. (05/11/17); Deutsche Bank (07/19/17). BNEF, "March 2018 PV Index: Supply, Shipments and Prices" (April 2018).

Module Average Selling Price—Global vs. U.S.

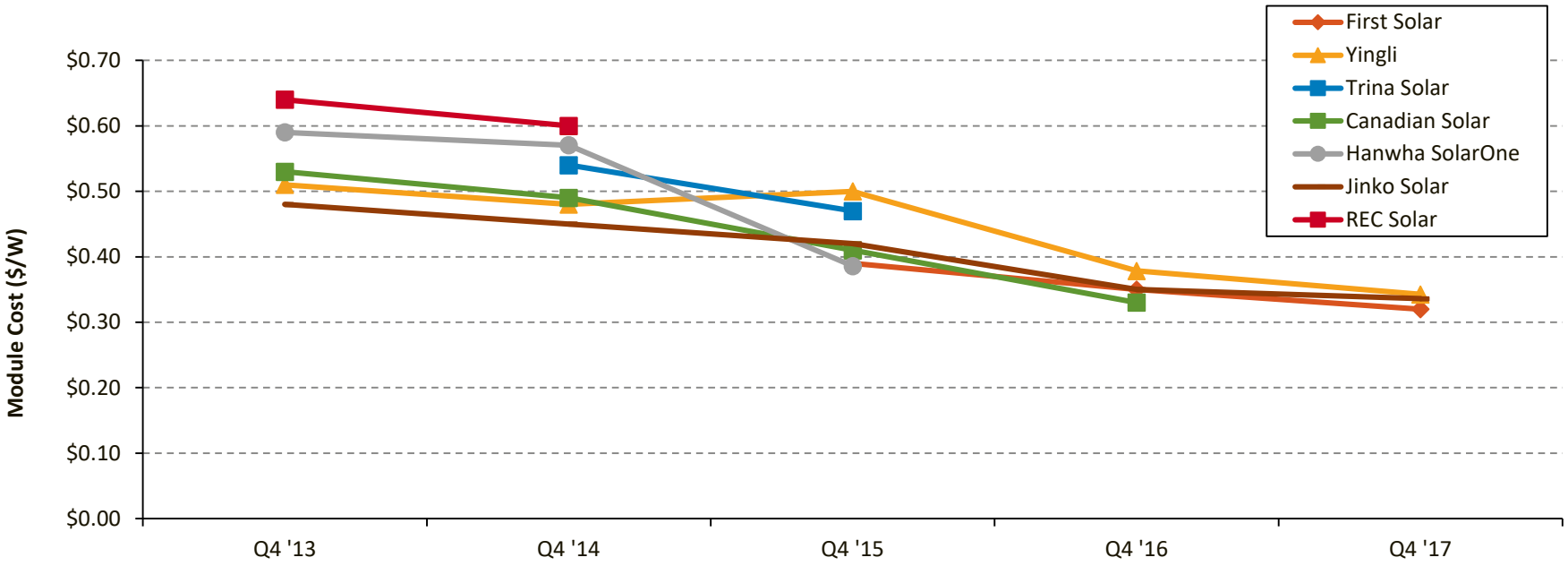


- Since tariffs were placed on Chinese modules in 2012, modules in the United States have sold at a premium to the global average; this trend was narrowing through 2016 due to increased manufacturing capacity in other parts of Asia.
- In 2017, the price gap widened again due to market fears of another tariff being placed on imported cells and modules.
  - Modules sold in the United States in Q4 2017 were 26% higher than modules sold in the United States in Q1 2017 and 52% higher than the global average.

Sources. U.S. (GTM Research / SEIA); Global (PV Insights / Mercom).

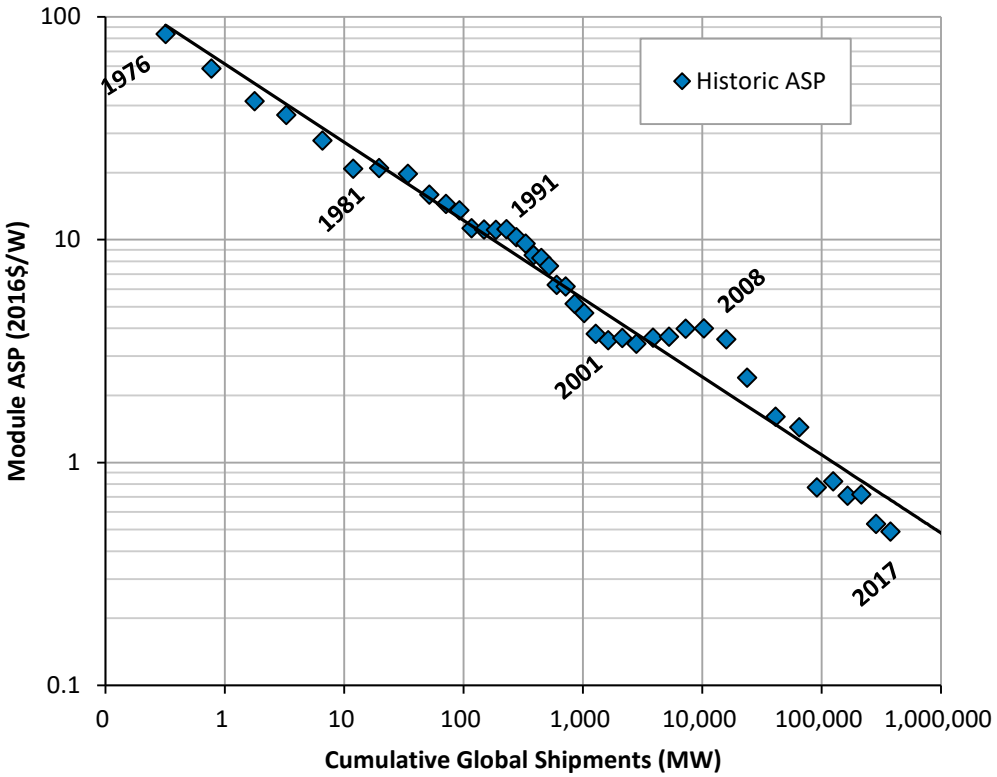
PV Manufacturers' Cost

In Q4 2017, module costs were reported between $0.33 and $0.35. As prices have come down, fewer and fewer companies are reporting prices.



Sources: Company figures based on Q4 2017 (and previous) SEC filings by the respective companies. Deutsche Bank (07/18/17 (02/25/18).

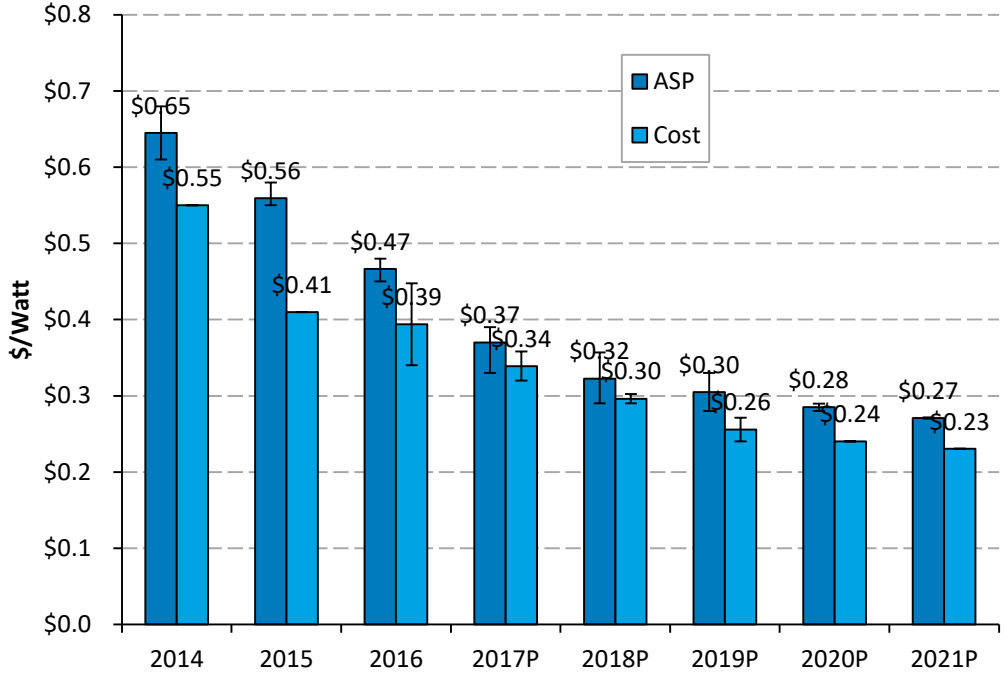
PV Experience Curve



- This experience curve displays the relationship, in logarithmic form, between the average selling price of a PV module and the cumulative global shipments of PV modules. As shown, for every doubling of cumulative PV shipments, there is on average a corresponding ~22% reduction in PV module price.
- Since 2012, module ASP has been below the historical experience curve.

Source: 1976-2017: Paula Mints. "Photovoltaic Manufacturer Capacity, Shipments, Price & Revenues 2017/2018." SPV Market Research. Report SPV-Supply6. April 2018.

Near-Term Module Price/Cost Projections

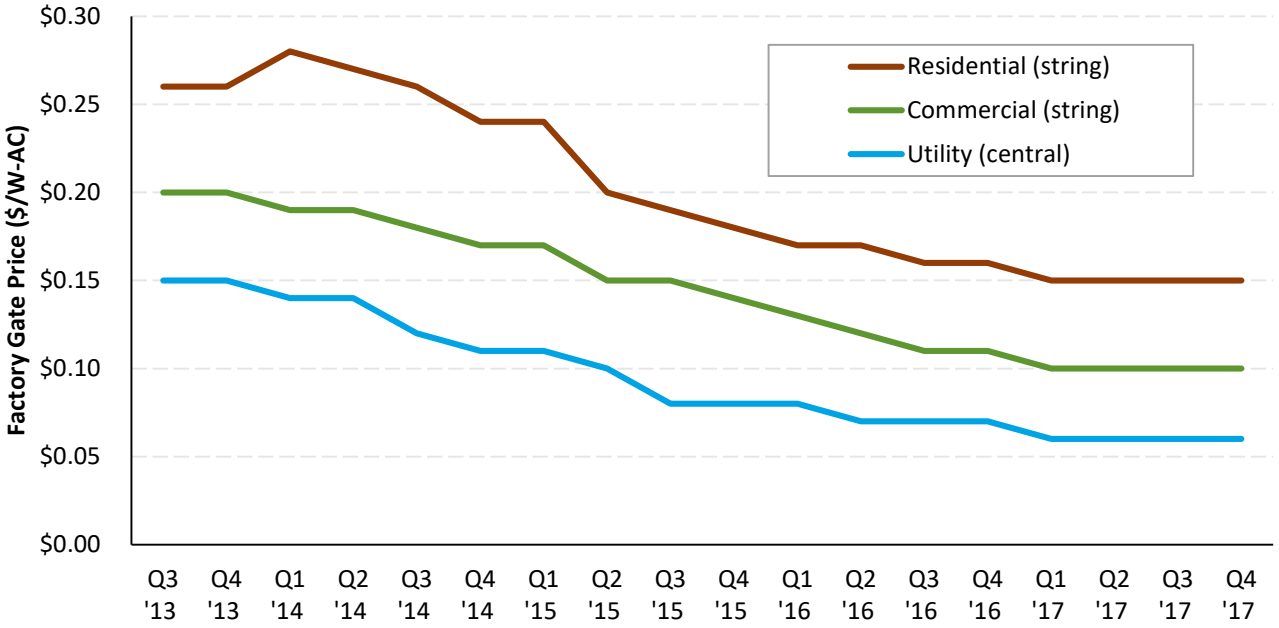


- Recent analyst reports indicate global module prices and costs are expected to continue to drop in the next few years.
- Regional module preferences and tariffs could impact actual pricing in the United States, Europe, India, and elsewhere.

Sources: Lines represent the median estimates, and error bars represent the maximum and minimum, ASP and costs for First Solar and industry averages from the following analysts: BNEF (February 2018); Deutsche Bank (February 2018); Goldman Sachs (May 2017, January 2018); GTM Research (December 2017).

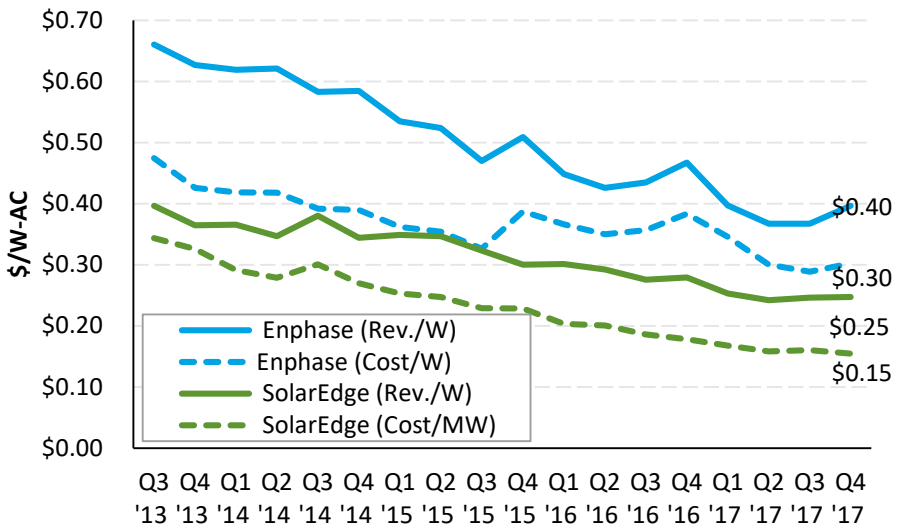
Inverter Pricing

- Since Q3 2016, the decrease in inverter price has slowed.
  - In 2017, string and central inverters have been flat.



Source. GTM Research / SEIA

Enphase Microinverters and SolarEdge DC-Optimized Inverter Systems

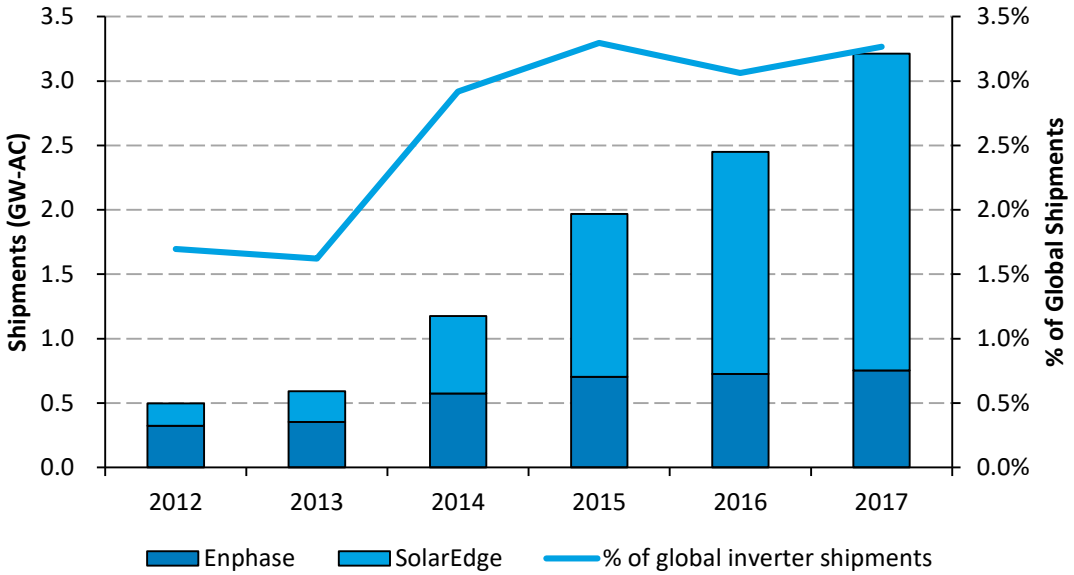


- In 2017, module-level power electronics (MLPE) price and costs were at historical lows and shipments were at historical highs—companies are expanding into new markets, growing shipments but also growing competition.
  - From Q4 2016 to Q4 2017, Enphase and SolarEdge MLPE prices fell 15% and 11%, respectively.
  - Enphase and SolarEdge MLPE costs also decreased by 21% and 13%, respectively, over the same period.
  - These companies have cut operating costs and are transitioning to more advanced technologies to better compete in this highly competitive marketplace.

Note: Starting in Q2 2017 Enphase switched reporting shipments from W-AC to W-DC; we adjust these values using an ILR of 1.1,

Sources: Corporate filings.

Enphase Microinverters and SolarEdge DC-Optimized Inverter Systems



- Enphase and SolarEdge shipped over 3 GW-AC of MLPE combined in 2017.
  - Since 2015, Enphase shipments have been relatively flat while SolarEdge shipments have grown 40% per year.
  - In Q4 2017, SolarEdge's MPLE product was approximately $0.15/W cheaper than Enphase's product.
- Enphase and SolarEdge represented approximately 3.3% of all inverter shipments in 2017.
  - GTM Research reports that these companies represented approximately 66% of U.S. residential PV system inverters installed in 2017—up from 57% in 2016.

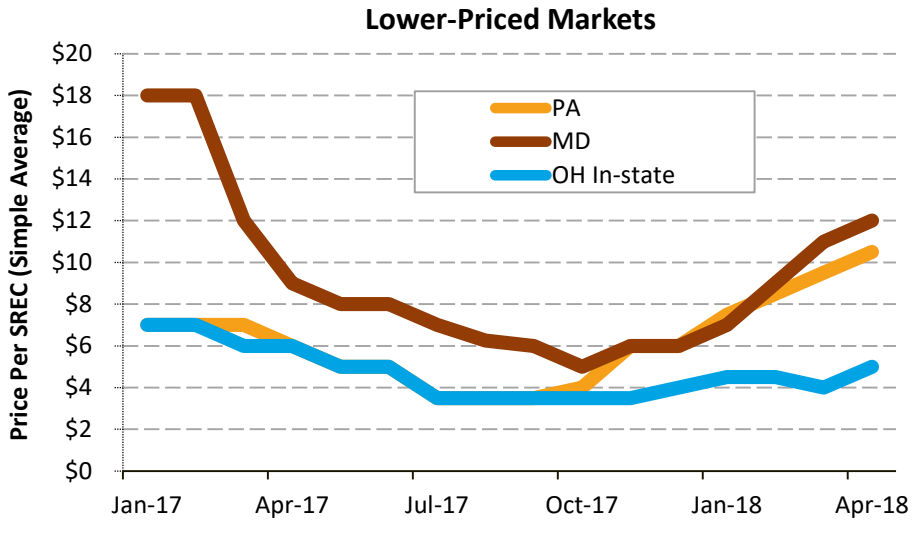
Sources: Corporate filings; GTM Research "U.S. PV Leaderboard Q1 2018"; PV Magazine (April 6, 2018).

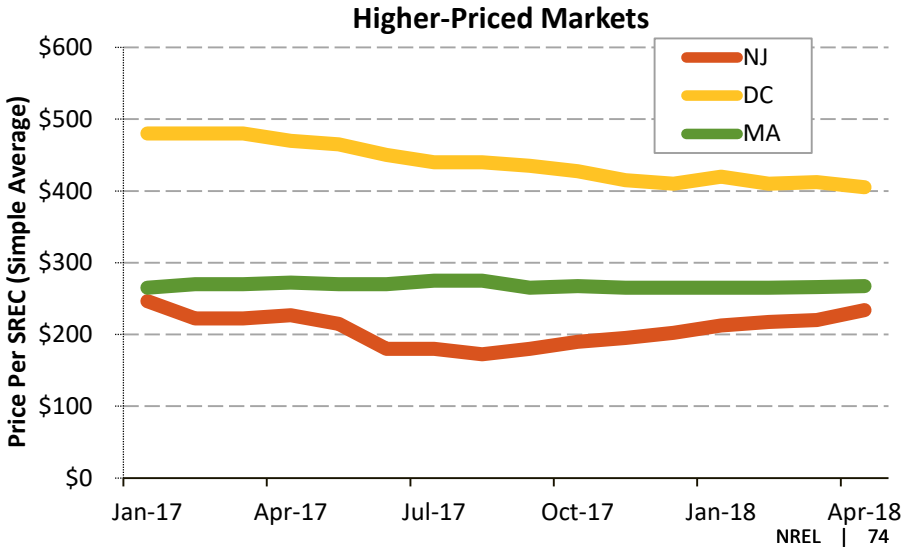
- **After falling in 2017, SREC pricing in most markets rebounded in the fourth quarter of 2017 and first quarter of 2018.**
- **In 2017, solar stocks, on average, performed much better than the broader market.**
  - **In 2018, solar stocks, on average, performed similar to the broader market, down 2%.**

SREC Pricing

- After falling in 2017, SREC pricing in most markets rebounded in Q4 2017 and Q1 2018.
- In late 2017, Pennsylvania passed a law prohibiting future out-of-state facilities from selling PA SRECs. While some out-of-state facilities have been grandfathered into the market for a certain period of time, PA SRECs have increased by 150% in 6 months.

- In April 2018, New Jersey passed legislation to increase its RPS to 50% by 2030 and behind-the-meter solar to 5.1% by 2021.
  - The bills close the SREC program in 2021 and direct regulators to move to a different program for distributed solar.
  - The bills set storage targets of 600 MW in 2021 and 2 GW in 2030.
  - SACP compliance payments were lowered starting in EY 2019.



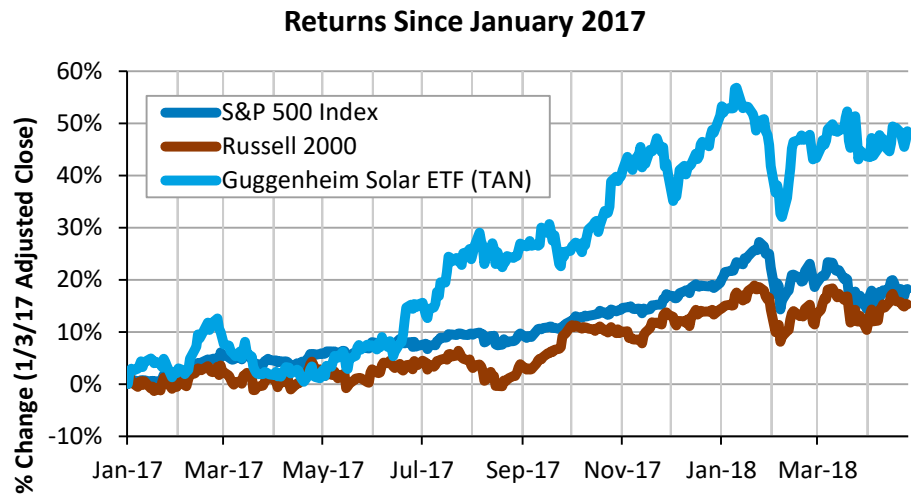


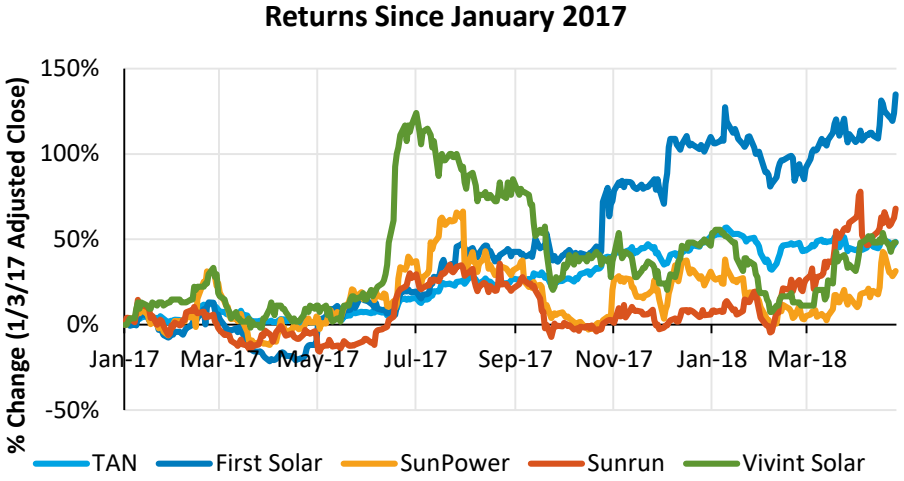
Sources: SRECTrade, www.srectrade.com (accessed 04/27/18); PV Magazine (April 2018).

Stock Market Activity

- In 2017, solar stocks, on average, performed much better than the broader market.
- In 2018, solar stocks, on average, performed similar to the broader market, down 2%.

- Since the beginning of 2017, some U.S. solar stocks have performed better than others due to a variety of reasons.
  - First Solar has benefited from the trade case and the successful rollout, to date, of its advanced modules.
  - Sunrun has executed its growth strategy and in Q4 2017 become the largest U.S. residential installer.
  - SunPower's stock has fluctuated, in part, due to uncertainties over the U.S. trade case, a market where it receives the vast majority of its income.





Source: Stock market: Yahoo Finance (01/29/18).

Thank You

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Special thanks to: Sarah Kurtz, Parthiv Kurup, Jeff Logan, Mary Lukkonen, Mark Mehos, Mike Meshek, Dave Mooney, and Craig Turchi.

List of Acronyms and Abbreviations

- AC alternating current
- ASP average selling price
- B billion
- BNEF Bloomberg New Energy Finance
- CAPEX capital expenditures
- CO_2 carbon dioxide
- C-Si crystalline silicon
- CSP concentrating solar power
- DC direct current
- DPU department of public utilities
- DPV distributed photovoltaic system
- EIA Energy Information Administration
- ETF exchange traded fund
- EU European Union
- FiT feed-in-tariff
- G&A general and administrative expenses
- GW gigawatt
- IBC interdigitated back contact
- IPP independent power producer
- ITC investment tax credit
- kW kilowatt
- kWh kilowatt-hour
- LCOE levelized cost of energy
- MLPE module-level power electronics
- MM million
- MW megawatt
- MWh megawatt-hour
- NEM net energy metering
- O&M operation and maintenance
- PERC passivated emitter rear cell
- PPA power purchase agreement
- PSC public service commission
- PV photovoltaic
- Q quarter
- R&D research and development
- ROW rest of world
- RPS renewable portfolio standards
- SEC United States Securities Exchange Commission
- SG&A selling, general, and administrative expenses
- SREC solar renewable energy certificate
- UPV utility-scale photovoltaic system
- USITC United States International Trade Commission
- W watt
- WTO World Trade Organization
- y/y year over year