Executive Summary

- The United States installed 4.5 GW$_{dc}$ of PV in H1 2017—cumulative capacity reached 45.4 GW.
  - Analysts estimate the United States will install between 8.5GW and 12.5 GW in 2017.

- On September 22, the U.S. International Trade Commission (USITC) found that the domestic U.S. module and cell manufacturing industry had been seriously harmed by imports. The commissioners released proposed remedies in late October less severe than what the petitioners requested, and will officially file its proposal on November 13th, but it is up to the president to determine whether to put tariffs in place.
  - Analysts estimate a significant tariff could reduce U.S. PV demand by 36%–43% between 2018 and 2021.

- Utah and New Hampshire are the latest of approximately nine states to adopt successor programs to net metering, lowering the value of exported solar energy to the grid.

- Recent estimates for 2017 global PV demand ranged from 81 GW to 103 GW.
  - China (~42 GW), the United States (~11 GW), and India (~9 GW) are projected to be the largest markets in 2017.

- Most data suggest that U.S. PV system pricing, across market segments, continues its downward trajectory.
  - U.S. PV system pricing remains higher than in much of the world, including other developed regions.

- As of Q3 2017, the global ASP* for PV modules was approximately $0.32/W—U.S. pricing was approximately $0.10/W higher due to existing U.S. tariffs and stockpiling by companies in case of new tariffs from the Section 201 trade case.

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

- State and Federal Updates
- Global PV Deployment
- U.S. PV Deployment
- PV System Pricing
- Global Manufacturing
- Component Pricing
- Market Activity
History of Current U.S. Solar Tariffs

- After a 2011 complaint by SolarWorld and six other companies, the USITC and the U.S. Department of Commerce investigated and then placed tariffs on Chinese panels with Chinese-made cells.
- This led to Chinese companies sending wafers to Taiwan and then shipping Taiwanese cells back to China. SolarWorld made a second complaint, which led to wider tariffs on Chinese panels/Taiwanese cells.
- China also placed tariffs on U.S. polysilicon (average 55%), which was widely viewed as a retaliatory measure.
- The United States currently has two kinds of tariffs on Chinese and Taiwanese panels:
  - Anti-Dumping Tariffs: a punitive tariff placed on countries that sell below cost to gain market share
  - Countervailing Duties: a punitive tariff placed on countries that receive “unfair” government subsidies
- The two tariffs differ for individual companies based on the extent to which the USITC believes they were involved in the practice.

Timeline

<table>
<thead>
<tr>
<th>Year Enacted</th>
<th>Type:</th>
<th>Product:</th>
<th>Average Tariff</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>AD/CVD</td>
<td>Chinese cells and modules made with Chinese cells</td>
<td>~25%</td>
</tr>
<tr>
<td>2014</td>
<td>AD/CVD</td>
<td>Taiwan cells and Chinese modules made with Taiwan cells</td>
<td>~65%</td>
</tr>
<tr>
<td>2018</td>
<td>?</td>
<td>All imported solar cells and modules</td>
<td>?</td>
</tr>
</tbody>
</table>

Section 201 Solar Trade Case

• One of the most important developments in the U.S. solar industry is the possibility that significant new tariffs will be placed on imported solar cells and panels early next year.

Global PV Production and U.S. Market Share

• U.S. solar manufacturing shipments have steadily increased but at a much slower rate than demand has risen.
• This gap is filled by imports, most of which are from Asia. Asia’s production has been increasing dramatically since 2007.
• Due in part to a fall in global prices, American solar manufacturers have struggled to become profitable, and a number of plants have closed.
Section 201 Trade Case

• Section 201 of the Trade Act of 1974 allows the United States, based on international trade law, to put temporary “safeguard” measures in place to protect domestic industry from foreign competition.

• Suniva requested the investigation after filing for bankruptcy in April 2017. SolarWorld joined the case in May.

• On September 22, 2017, the USITC found that the domestic U.S. module and cell manufacturing industry had been seriously harmed by imports. The commissioners released proposed remedies in late October less severe than what the petitioners requested, and will officially file its proposal on November 13th, but it is up to the president to determine whether to put tariffs in place.

• Safeguards can be initially imposed for four years, and they can then be renewed for another four years, up to a maximum of eight years.

• Remedies would apply to all imports but might exclude countries with whom the United States has special trade deals (e.g., Canada and Korea).
  – However, the USITC did find injury for imports from Mexico and Korea, though not for Canada or Singapore.

Differences between Trade Cases

Section 201
• Applied to all countries
• No “wrongdoing” by other countries required
• Higher standard for harm
• Highly political

AD/CVD
• Applied to one country
• Requires dumping or subsidies
• Lower standard for harm
• Bureaucratic process

The Process

A company requests a 201 investigation from the ITC

Do they have standing?

\[ \text{Yes} \rightarrow \text{Investigation! Was there ‘serious harm’ and were imports a ‘substantial cause’?} \]

\[ \text{No} \rightarrow \text{Case Ends} \]

\[ \text{Yes} \rightarrow \text{Recommendations sent to the president, who can accept them, deny them, or put different safeguards in place instead} \]

\[ \text{No} \rightarrow \text{Case Ends} \]

Trade organizations, unions, the President, congress, or the ITC itself can also request investigations

To have ‘standing,’ the organization must represent a significant fraction of the industry.

To be a ‘substantial cause’ the impact of imports must be significant and not less than any other cause.

Projected Impact of tariffs

- Suniva originally requested a 40¢/W tariff on PV solar cells and a 78¢/W floor price on PV solar modules, which is the basis for the analysis below.
- They recently revised their request to a 25¢/W tariff for PV solar cells, a 32¢/W tariff on PV modules, and a floor price of 74¢/W on PV modules.

**Impact on Installed Capacity**

**2018–2021 U.S. PV Demand (GW)**

<table>
<thead>
<tr>
<th>Year</th>
<th>No Tariff</th>
<th>20¢/W tariff</th>
<th>40¢/W tariff</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>2019</td>
<td>55</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>2020</td>
<td>50</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>2021</td>
<td>45</td>
<td>35</td>
<td>25</td>
</tr>
</tbody>
</table>

**Impact on Jobs**

**SEIA**

"An estimated 88,000 jobs, about one-third of the current American solar workforce, would be lost..."

**Mayer Brown (Suniva’s lawyers)**

"An affirmative finding... would result in a net gain in employment of at least between 114,796 and 144,298"

**Note:** Mayer Brown’s jobs estimate is relative to today not to a future without new tariffs. Mayer Brown’s estimates are based on a GTM research study, but they are also highly critical of that study’s results.

Growing U.S. solar demand has been largely met by module and cell imports, mostly from Asia.

- The value of U.S. imports of PV modules and cells grew by three times from 2010 to 2016, while the approximate imports (GW) grew by nine times.
  - Imports grew faster in terms of GWs than dollars because of the reduction in price.
- Since 2012, Chinese imports have remained relatively flat by dollar value, though China has shipped more panels.
- In 2016, approximately 48% of module and cell value entering the United States came from South East Asia (62% of which came from Malaysia).
- Given the surplus of PV shipments into the United States the past seven years relative to installation levels, the United States likely has significant cell and module inventory should a tariff be put in place on foreign PV equipment in the future.

**Note:** GW of imports calculated by dividing the dollar value of imports by global module and cell ASP, plus 10% (to account for measures taken by companies to circumvent existing U.S. tariffs).

State Actions on Distributed Solar

Forty-one states and Washington, D.C. took 142 separate actions on distributed solar policy and rate design during Q3 2017.

Since 2015, several states have lowered the credited value of exported electricity from DG PV.

- Utah and New Hampshire are the latest states to adopt successor programs to net metering, lowering the value of exported solar energy to the grid.
- Michigan recently opted to continue net metering at the current compensation scheme until a successor can be approved.
- Seventeen states took action in Q3 2017 related to the development of a net metering successor tariff or adjusting credit rates for excess generation.

**Sources:** North Carolina Clean Energy Technology Center, *The 50 States of Solar: Q3 2017 Quarterly Report*, October 2017; PV Magazine (02/02/17, 06/19/17; 06/26/17); Utility Dive, 06/26/17.
Agenda

• State and Federal Updates
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• Global Manufacturing
• Component Pricing
• Market Activity
Analysts expect the rapid growth of the PV industry to continue in the near term.

Recent estimates from analysts reported that global PV demand in 2017 will range from 81 GW to 103 GW, with a median of approximately 90 GW—a 17% increase from 2016 global installations. This installation level would bring the cumulative total to ~400 GW.

- China (~42 GW), the United States (~11 GW), and India (~9 GW) are projected to be the largest markets in 2017.

Annual global installations are projected to grow to by 104 GW–127 GW by 2021.

- Median analyst figures estimate that 514 GW of PV will be installed globally from 2017 to 2021, with China, the United States, and India representing a large part of demand.

- The majority of the growth is expected to come from emerging markets (ROW).

Note: P = projection. Bar represents median projection. Error bars represent high and low projections.
Sources: Data displayed represent the median figures from the following sources: BNEF (08/18/17); Cowen & Co. (09/14/17); Deutsche Bank (10/03/17); GTM Research (July 2017); IHS Markit, Technology Group, PV Demand Market Tracker, September, 2017.
Key Markets Update

- The leading global PV markets, in most cases, had record levels of PV demand in H1 2017; analysts expect a very large second half of the year as well.

- China, with 25 GW, was by far the world’s largest market in H1 2017.
  - Similar to H1 2016, Chinese companies rushed to qualify for higher FIT.
  - The United States (4.5 GW) and India (4.7 GW) had their largest first six months ever, while Japan contracted for the second straight year.
  - In H1 2017, the United States surpassed Germany to become the third-largest PV market, and it also surpassed Germany and Japan to become the second largest solar market (when CSP is included).

- The United States is expected to have a larger proportion of installs in H2 2017 than other leading countries; however, China’s H2 2017 installs are expected to dwarf all other countries’ total year deployment.

Note: P = projection for second half of 2017

• Approximately 1.2 billion people have no access to an electrical grid and spend $27 billion 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.

• 8.1 million portable solar products were sold in 2016 for $253 million.
  – 2016 sales represent a 16X increase from 2011.
  – 30.7 million products have been cumulatively sold since July 2010, providing over 100 million people with improved energy access and $5.2 billion in energy savings over the lives of the products.
  – 50% of sales in H1 2017 were in sub-Saharan Africa and 31% 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.

• The downturn in demand for off-grid solar in H2 2016 and H1 2017 was attributed to demonetization that occurred in India in November 2016 (causing cash constraints) and drought in East Africa (increasing the cost of living and decreasing purchasing power), as well as to market growing pains.

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 2017, products with a capacity of less than 3 W represented 81% of reported sales.

<table>
<thead>
<tr>
<th>Product Size (Watts)</th>
<th>Use</th>
<th>% of H1 2017 Market Revenue*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–1.5</td>
<td>Single light only</td>
<td>13%</td>
</tr>
<tr>
<td>1.5–3</td>
<td>Single light and mobile charging</td>
<td>68%</td>
</tr>
<tr>
<td>3–10</td>
<td>Multiple lights and mobile charging</td>
<td>12%</td>
</tr>
<tr>
<td>11–20</td>
<td>Solar home system (SHS), entry level (3–4 lights, mobile charging, powering radio, fan, etc.)</td>
<td></td>
</tr>
<tr>
<td>21–49</td>
<td>SHS, basic capacity (above plus power for TV and extended capacity)</td>
<td>4%</td>
</tr>
<tr>
<td>50–100</td>
<td>SHS, medium capacity (above but with extended capacities)</td>
<td></td>
</tr>
<tr>
<td>100+</td>
<td>SHS, higher capacity (above but with extended capacities)</td>
<td></td>
</tr>
</tbody>
</table>

*Figures do not add to 100% in report.
Agenda

- State and Federal Updates
- Global PV Deployment
- U.S. PV Deployment
- PV System Pricing
- Global Manufacturing
- Component Pricing
- Market Activity
Analysts project that U.S. PV installation levels from 2018 to 2021 will largely depend on whether there is a U.S. tariff and, if so, the size of the tariff. Estimates of total four-year deployment range from 27 GW to 64 GW.

- Under a 20¢/W tariff, the median analyst projection indicates a ~15% reduction in demand from 2018 to 2021, with distributed and utility-scale deployment being affected roughly the same.
- Under a 40¢/W tariff, the median analyst projection indicates a 36%–43% reduction in demand from 2018 to 2021, with utility-scale being most affected (40%–49%), followed by commercial scale installations (36%–44%).
- In addition to a tariff, analysts believe that U.S. PV demand would also be affected by a cap on imports or minimum module-sales price.

New PV activity in the United States is already being affected, as projects without a guaranteed module supply are being put on hold until there is a resolution in the trade case—many module suppliers are sold-out through 2018.

Note: P = projection. Bar represents median projection. Error bars represent high and low projections
Sources: 2013–2016 data from GTM Research (October 2017); 2017-2021 data displayed represents the median figures from the following sources: BNEF (10/18/17); GTM Research (October 2017); IHS Markit, Technology Group, PV Integrated Market Tracker, October, 2017.
The United States installed 4.5 GW$_{DC}$ of PV in H1 2017 (up 5% y/y) — cumulative capacity reached 45.4 GW.

- Q2 2017 represents the 15th-straight 1 GW+ quarter and 7th-straight 2 GW+ quarter.
- The 17% reduction in residential PV installs in H1 2017 was compensated for by the 30% and 12% increase in non-residential and utility-scale PV installations, respectively.

In H1 2017, the top five states represented 58% of the market (63% in 2016) — 24 states installed more than 25 MW, 10 states had more than 1 GW of cumulative PV capacity.

Leading residential PV integrators are losing market share and diversifying sales.

In 2014 and 2015 the leading three residential integrators more than tripled their quarterly installations.

Since then, these companies’ installations have stagnated or shrunk.

- Large integrators are pursuing profitability over growth. Tesla has stopped door-to-door sales.

Starting in 2015 and 2016, Tesla, Vivint Solar, and Sunrun are deploying a significantly higher proportion of direct sales or loans versus their traditional PPA and lease offerings.

- Tesla and Sunrun are also expanding product offerings through PV+storage.
  - Tesla has installed 255 MWh of storage in the past three quarters.

In 2017, the U.S. residential market has contracted due to customer acquisition challenges, large integrators’ pursuit of profitability, and challenges in leading markets, such as California.

- H1 ’17, U.S. residential PV installs are down overall y/y; however, they are still much larger than they were in all years preceding 2016.


Note: Tesla Q4 2016 through Q2 2017 residential deployment are assumed to have the same percentage of total deployment that occurred in Q3 2016.
RPS No Longer Driving Solar Demand

- Historically, RPS requirements have driven the majority of U.S. solar deployment; however, as of June 2017, 64% of projects in development were driven by non-RPS mechanisms.

- Due to significant reductions in cost, utility-scale U.S. PV deployment is being driven by other factors.

- In 2016, PURPA* was the largest driver of utility PV procurement; however, recent reforms in key markets may minimize the impact of PURPA in the future.

- SEIA and GTM Research expect voluntary procurement to be the largest driver of utility procurement in the near future, with utilities outlining 11 GW of additional PV planned non-RPS procurement.

*PURPA is a U.S. federal law passed in the 1970s which requires electric utilities to purchase electricity from “qualified facilities”, such as solar PV, at the “avoided cost” of energy. It’s up to states to implement PURPA and each state has different standards as to the value of avoided cost, the length of procurement, and the maximum system size.

Community solar programs are active across the United States and are one of the fastest growing PV market segments.

SEIA and GTM Research report that the non-residential market will be the only segment to grow in 2017 in part due to the strength of community solar and other offsite PV deployment strategies.

MW = megawatts AC

Offsite Corporate Procurement of PV

- Offsite corporate procurement is an innovative business solution that has become a driver of large-scale PV deployment.

- The Rocky Mountain Institute (2017) found that all corporate renewable deals rose from 50 MW in 2012 to 1.48 GW in 2016. This trend appears to be continuing with over 2 GW of deals completed in the first nine months of 2017.

- There are several advantages of offsite corporate procurement:
  - Many corporations (e.g., data centers) use a lot of energy, have limited onsite resources, and have aggressive sustainability goals.
  - With the reduction in cost, investment in PV assets can offer an additional source of profitability.
  - Long-term energy contracts can limit their exposure to energy price volatility.

Source: Rocky Mountain Institute 2017

Corporate Renewable Deals 2012 – 2017
Offsite Corporate Procurement Contracts

There are several methods for contracting offsite corporate procurement, which depend on market structure and customer preference.

- **Virtual PPAs** (e.g., “fixed-for-floating swap”, “contract for differences”) allow PV developers and businesses to hedge against the electricity market without actually selling each other electricity.
  - Virtual PPAs rely on a wholesale market and are not contracted with the utility.
  - Typically, the closer the PV system is to the company’s load, the better the hedge.

- **Sleeved PPAs** (e.g., utility green tariff, back-to-back PPA) are three-way contracts between the corporation, the corporation’s electric utility, and the PV system owner.
  - Two PPAs: one between the customer and the utility and one between the utility and the PV system owner.

While they can be complicated, time-consuming and costly to set up, there are many benefits of sleeved PPAs:
- Corporations lock-in a price hedge without any wholesale market risk.
- Developers often have an easier time financing the PV project due to a stronger credit profile.
- Electricity service providers lock in electricity load.

**Summary of Virtual PPA transactions**

- **Sleeved PPAs** (e.g., utility green tariff, back-to-back PPA) are three-way contracts between the corporation, the corporation’s electric utility, and the PV system owner.
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While they can be complicated, time-consuming and costly to set up, there are many benefits of sleeved PPAs:
- Corporations lock-in a price hedge without any wholesale market risk.
- Developers often have an easier time financing the PV project due to a stronger credit profile.
- Electricity service providers lock in electricity load.

Batteries are a small but growing tool to help utilities and customers manage variable generation.

- Pumped-hydro continues to be the largest source of energy storage in the United States by an order of magnitude; however, a significant amount 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.

- Tesla and Sunrun are also expanding product offerings through PV + storage.
  - Tesla has installed 255 MWh of storage in the past three quarters.
  - Sunrun has announced 20 MWh of orders received for energy PV + storage. “Storage and other advanced technologies add greater value than solar alone and are best addressed with monthly billing models from a dedicated service provider [Sunrun].”

**Source:** EIA “Electric Power Monthly,” Table 6.1. Electric Generating Summer Capacity Changes (MW).
SEPA reports there were 661 MWh (622 MW*) of battery storage in the United States at the end of 2016, approximately one-third of which was installed that year.

In 2016, 71 different utilities had at least one energy storage installation, 31 of which employed their first energy storage project in 2016.

Five New Things to Know from *Tracking the Sun X*

1. TPO share of U.S. installs dropped to 58% in 2016, reflecting broader market trends back toward customer ownership (Chart 1).

2. Despite the smaller system size and premium modules, PV systems installed in new construction offer a significant price advantage.

3. The median efficiencies for modules installed in residential U.S. PV systems grew from 12.7% to 17.3% from 2002 to 2016 (Chart 2). Increasing module efficiencies and system sizes are together responsible for roughly a $1.0/W reduction in residential system costs over the long term (12% of the total decline in residential installed prices).

4. Within each of the five states shown in Chart 3, installer-level median prices differ by $0.7/W to $1.4/W between the 20th and 80th percentiles (and by more across the full set of installers).

5. In general, there is little price difference and no consistent directional trend based on installer volume.

Five New Things to Know from *Utility-Scale Solar 2016*

1. With increasing solar penetration in California, solar curtailment has increased while solar’s wholesale energy value has declined (Chart 1). In 2012, when solar penetration was ~2%, solar earned 126% of the average wholesale power price; in 2016, with solar penetration at ~12%, solar earned just 83% of the average wholesale power price.

2. O&M costs appear to be declining, over the long-term, to $17.8/kW-year in 2016 (Chart 2).

3. Fleet-wide PV capacity degradation appears to exceed the 0.5%/year benchmark commonly assumed in PPAs and pro forma models (Chart 3).

4. Utility-scale PV projects with tracking increased in dominance (79% of newly installed capacity) relative to fixed-tilt projects (21%) in 2016, offering higher production with a price premium of only $0.15/W. With lower module prices, developers have oversized the DC array capacity relative to the AC inverter capacity (i.e., the ILR) to enhance revenue.

5. There is a strong percentage growth in PV deployment outside the established markets in place such as Georgia, Florida, and Texas.

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Most data suggest that PV system pricing, across market segments, continues its downward trajectory.

There are a variety of ways that U.S. PV system pricing, or costs, are estimated and quoted, including:

- Reported price (backward-looking)
- Reported costs (backward-looking and may not include profit, unless incorporating “value”)
- Developer quotes (forward-looking)
- Bottom-up cost benchmarking (forward-looking).

In 2016, the range in average U.S. PV system pricing across methods was reported to be:

- $2.78/W to $4.61/W for residential
- $1.62/W to $3.46/W for non-residential
- $1.06/W to $1.69/W for utility-scale.

In the first half of 2017, the range in average U.S. PV system pricing across methods was reported to be:

- $2.55/W to $4.47/W for residential
- $1.53/W to $2.98/W for non-residential
- $0.96/W to $1.64/W for utility-scale.
Reported, Bottom-Up, and Analyst-Projected Average U.S. PV System Prices over Time

- All methodologies show a downward trend in PV system pricing.
- Historically, reported pricing and modeled benchmarks had similar results; however, residential PV system price estimates have recently diverged over time.
- Analysts expect system prices to continue to fall with commercial PV approaching, and utility-scale PV exceeding, SunShot targets by 2022.

**Note:** Reported prices represent the median national U.S. averages. Error bars represent the high and low analyst expectations.

**Sources:** Reported residential and commercial system prices (Barbose and Dargouth 2017); reported utility system prices (Bolinger, Seel, LaCommare 2017); modeled system prices (Fu et al. 2017); analyst expectations (Cole et al. 2017); The Global Module Price Index is the average module selling price for the first buyer (P. Mints SPV Market Research); analyst expectation of module price (see Slide X).
2016 Modeled, Reported, and Quoted System Price from Various Sources

- NREL and LBNL PV system pricing figures are consistent with other sources.
- Across various sources, reported system pricing is generally higher than modeled system pricing.

**Note:** Some sources only report a range, which is represented by the error bars.

Variation in Reported Price by State: Residential and Non-Residential PV Systems in 2016

- Some of the largest markets (California, Massachusetts, and New York) are relatively high-priced, pulling overall U.S. median prices upward.
- Pricing in most states is below the national median.
- Cross-state variation may reflect differences in installer competition and experience, retail rates and incentive levels, project characteristics particular to each region, labor costs, sales tax, and permitting and administrative processes.
- A high degree of variability also occurs within states.

Since 2007-2009, the median installed price of utility-scale PV has fallen steadily, by over 65%, to around $2.2/W_{AC}$ ($1.7/W_{DC}$) in 2016.

- From 2015 to 2016, the median installed price of utility-scale PV fell 22% (19% in $/W_{DC}$).

80% of reported utility-scale PV system prices in 2016 were below $2.53/W_{AC}$ ($1.91/W_{DC}$).

This sample is backward-looking and may not reflect the price of projects built in 2017–2018.

• From 2010 to 2017, modeled system prices fell 15%–26% per year.
  – 48%–62% of reduction attributed to module price reductions

• From 2016 to 2017, modeled system prices fell between $0.18/W and $0.43/W, or 6%–29%.
  – Modeled residential system price reductions in 2017 were not as great as in commercial and utility-scale markets due to increased soft costs related to module supply chain, such as historical inventory.

• Modeled soft costs are generally increasing as a proportion of the total price for distributed PV systems.
  – 59% and 68% of modeled system price for commercial and residential systems respectively

• The Q1 2017 bottom-up modeled residential system costs of $2.80/W is consistent with leading residential installers’ costs, such as Sunrun’s ($2.92/W) and Vivint’s ($2.98/W) reported Q1 2017 costs.

Financing Cost Benchmarking

NREL estimates that in 2017 the cost of capital for large projects, or portfolios of projects (large and distributed), averages 7.2% and 7.6% respectively.

- Tax equity is currently the most expensive source of capital, with the exception of some sources of sponsor equity, while debt is the least expensive.

- Smaller-scale transactions have higher WACCs that average in the range of 7.2% to 13.7%.

- The cost of capital is not the only cost of financing borne by a project. NREL found that in addition to bearing the cost of capital, projects may also incur set-up costs averaging $1.1 million.

The reductions in total capital cost, along with improvements in operation, system design, and technology have resulted in significant reductions in the cost of electricity. U.S. residential and commercial PV systems are 86% and 89% toward achieving SunShot’s 2020 electricity price targets, and U.S. utility-scale PV systems have achieved their 2020 SunShot target three years early.

**Note:** The analysis uses the fixed-tilt systems for LCOE benchmarks from 2010-2015 and then switches to one-axis tracking systems from 2016 to 2017 to reflect the market share change in the utility-scale PV sector.

There has been a strong, steady downward PPA price trend since 2006, with an average levelized price signed in 2016 of ~$35/MWh.

- The median unsubsidized LCOE of utility-scale PV projects built in 2016 was below the DOE SunShot target of 6 cents/kWh.

California and the Southwest dominate the sample, but 2014–2016 saw a broadening of the market to Texas, Arkansas, Alabama, Florida—and even Minnesota and Michigan.

Three PPAs featuring PV plus long-duration battery storage do not seem to be priced at a prohibitive premium to their PV-only counterparts.

System Pricing from Select States

- From H2 2016 to H2 2017, the median reported system price for PV systems in Arizona, California, Massachusetts, and New York:
  - Fell 3% to $4.26/W, for systems 2.5 kW–10 kW
  - Fell 5% to $3.70/W, for systems 10 kW–100 kW
  - Fell 3% to $2.92/W, for systems 100 kW–500 kW
  - Increased 2% to $2.30/W, for systems 500 kW–5 MW.

- In H2 2017, the median reported system price for PV systems 2.5 kW–10 kW was 85% higher than the median price for systems 500 kW–5 MW
  - From H2 2014 to H2 2017, the median price of systems 2.5 kW–10 kW fell 12%, while the median price of systems 500 kW–5 MW fell 27%.

H2 2017 MW: AZ (2); CA (24); MA (3); NY (8).

Note: California pricing data before 2015 are collected from the California Solar Initiative database. CA NEM data have only been reported through July 2017.

Sources: CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; NY PV Incentive Program. All programs accessed 10/02/17.
In addition to price differences based on system size, there is also variation between states and within individual markets.

- In H2 2017, the median price of a small system in Arizona was about 12% less than the median price in California.
- In H2 2017, the 20th and 80th percentile prices in California for a system 100 kW–500 kW were $4.08/W and $2.39/W respectively.

**Note:** California pricing data before 2015 are collected from the California Solar Initiative database. CA NEM data have only been reported through July 2017.

**Sources:** CA NEM database; MA SREC program; Arizona Public Services and Salt River Project; NY PV Incentive Program. All programs accessed 10/02/17.
System Price Quotes Reported by EnergySage

- EnergySage reported an 11% reduction in the average gross costs of a residential system from H1 2016 to H1 2017.
  - The standard deviation of PV system quotes in H1 2017 was $0.47/W.
  - EnergySage quotes also reported an average system payback period of 7–8 years.
- Residential system quotes varied by state. In H1 2017, the average gross cost of a residential system in Rhode Island was 32% higher than the average gross cost of a residential system in Florida.

**Cost over Time**

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Gross Costs ($/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2 2014</td>
<td>$3.86</td>
</tr>
<tr>
<td>H1 2015</td>
<td>$3.79</td>
</tr>
<tr>
<td>H2 2015</td>
<td>$3.69</td>
</tr>
<tr>
<td>H1 2016</td>
<td>$3.57</td>
</tr>
<tr>
<td>H2 2016</td>
<td>$3.36</td>
</tr>
<tr>
<td>H1 2017</td>
<td>$3.17</td>
</tr>
</tbody>
</table>

**Cost by State, H1 2017**

<table>
<thead>
<tr>
<th>State</th>
<th>Average Gross Costs ($/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td>$2.6</td>
</tr>
<tr>
<td>VA</td>
<td>$2.7</td>
</tr>
<tr>
<td>OH</td>
<td>$2.8</td>
</tr>
<tr>
<td>AZ</td>
<td>$2.8</td>
</tr>
<tr>
<td>MD</td>
<td>$2.9</td>
</tr>
<tr>
<td>IL</td>
<td>$3.2</td>
</tr>
<tr>
<td>U.S.</td>
<td>$3.2</td>
</tr>
<tr>
<td>TX</td>
<td>$3.3</td>
</tr>
<tr>
<td>MI</td>
<td>$3.3</td>
</tr>
<tr>
<td>CA</td>
<td>$3.3</td>
</tr>
<tr>
<td>MA</td>
<td>$3.3</td>
</tr>
<tr>
<td>NY</td>
<td>$3.3</td>
</tr>
<tr>
<td>RI</td>
<td>$3.5</td>
</tr>
</tbody>
</table>

**Sources:** EnergySage “Solar Market Place Intel Report H2 2016 – H1 2017.”
System Prices from Sol Systems
500 kW–2 MW and 2 MW+

Sol Systems reports that from Q4 2016 to Q3 2017 the median all-in asking price for systems 500 kW–2 MW fell approximately 2%, and the median all-in asking price for systems greater than 2 MW fell 10%.

Sol Systems reports values on a monthly basis. Values for each quarter from Q2 2016 to Q3 2017 represent the average of the three monthly medians reported each quarter. Prior to Q2 2016 Sol Systems only reported a high and low value for each market segment; values prior to Q2 2016 represent the midpoint between the reported high and low value.

From Q2 ‘16 to Q2 ’17, Vivint Solar and Sunrun systems total costs decreased 2% and 10% respectively.

- Vivint Solar’s and Sunrun built installation costs decreased 15% and 18% y/y respectively to between $1.8/W and $1.9/W.
- Vivint Solar’s overhead costs increased from $0.81/W to $1.07/W over that time, while Sunrun’s overhead costs decreased from $1.19/W to $0.83/W. Vivint Solar’s quarterly installation levels have decreased while Sunrun’s quarterly installation levels have increased.

Source: Corporate filings
The price of residential systems in the United States remains higher than in much of the world, including other developed regions.

- An LBNL report cited non-hardware costs as the primary difference in distributed PV system pricing, owing to differences in market size, incentive levels and incentive design, solar industry business models, demographics and customer awareness, building architecture, systems sizing and design, interconnection standards, labor wages, and permitting and interconnection processes.

While U.S. utility-scale projects are higher than global averages, the gap is much smaller than it is in the residential sector.
A recent NREL study analyzed the impact that the SunShot 2030 targets\(^1\) would have on the United States and how its results would change with low-storage cost (LSC).\(^2\)

- It is estimated that if the SunShot 2030 cost targets are achieved, 405 GW of PV will be deployed by 2030 and 971 GW will be deployed by 2050 (33% of total generation).
  - With the addition of low-cost storage, PV is estimated to continue to achieve significant growth post-2030, resulting in 1,618 GW of PV by 2050—accounting for factors such as supply-chain constraints and changes in natural gas price, deployment could range from 1,148 GW to 1,923 GW.

- By 2050 electricity prices are projected to be 2% lower under the SunShot scenario, and 12% lower under the SunShot + LSC case.

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\(^1\)SunShot 2030 targets: 3¢/kWh for utility-scale PV, 4¢/kWh for commercial PV, 5¢/kWh for residential PV

\(^2\) Low-cost storage: ~$130/kWh, for an 8-hour battery, by 2030

Agenda

- State and Federal Updates
- Global PV Deployment
- U.S. PV Deployment
- PV System Pricing
- Global Manufacturing
- Component Pricing
- Market Activity
In the first half of 2017, the tracked companies shipped 15.2 GW, 32% more than were shipped in the first half of 2016.

- In Q2 ’17, the tracked companies shipped 8.9 GW.
- Jinko once again reported the largest shipments, with 5 GW shipped in H1 ’17.

Note: First solar reports production, not shipments.
Sources: Company figures based on Q2 2017 (and previous) SEC filings by the respective companies.
PV Manufacturers’ Margins

Margins improved slightly in Q2 2017, continuing their recovery after a significant fall in Q4 2016, when companies faced a significant decline in module prices and several went through restructuring.

- The median gross margin was 11% and the median operating margin was 2% for the above seven companies in Q2 2017.

Sources: Company figures based on Q2 2017 (and previous) SEC filings by the respective companies.
Privatization of PV Manufacturers

Since 2015, and especially in the past year, several PV manufacturers have gone private, although most of the top manufacturers continue to be public companies.

**Analyst Explanations**

- Low valuations have made it difficult for public solar companies to raise capital.
- Some analysts believe solar stocks on the New York stock exchange are undervalued, especially those for Chinese solar manufacturers. There is speculation that Trina and ReneSola will eventually re-list on an Asian stock exchange.
- ReneSola was at risk of being forced out of the New York Stock Exchange because of its low market capitalization. Shedding most of its debt should allow its downstream arm to continue being listed.

**Key Events**

<table>
<thead>
<tr>
<th>Company</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ReneSola</td>
<td>went private Q2 2017</td>
</tr>
<tr>
<td>JA Solar</td>
<td>offered buyout to shareholders Q2 2015, then again in Q2 2017</td>
</tr>
<tr>
<td>SolarWorld</td>
<td>entered bankruptcy in Q2 2017, emerged as private company</td>
</tr>
<tr>
<td>Trina Solar</td>
<td>went private Q1 2017</td>
</tr>
<tr>
<td>REC Solar</td>
<td>went private Q2 2015</td>
</tr>
</tbody>
</table>

**Sources:** Fillings and earning calls from relevant companies. Analyst reactions from SeekingAlpha.com, PV-Magazine.com, and PV-Tech.com
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In Q2 ’17, module costs were reported to be between $0.31/W and $0.36/W.
   - Q2 ‘17 costs for First Solar, Jinko Solar, and Yingli Solar were, on average, 17% less than Q1 ’16, though these three companies may not be representative of the industry as a whole.

As prices have come down, fewer companies are publicly reporting manufacturing costs.

Sources: Company figures based on Q2 ’17 (and previous) SEC filings by the respective companies.
Deutsche Bank (07/18/17)
Strong demand for PV in China and the stockpiling of modules in the United States due to the Section 201 filing by SolarWorld and Suniva have eliminated the glut of supply and stabilized pricing.

From January 2017 to September 2017, module prices for larger and small buyers fell 10% and 38%, while over the same period, poly, wafer, and cell prices increased 3%, 9%, and 5% respectively.

- In Q3 2017, poly pricing varied from $13/kg to $16/kg, making it harder for PV manufacturers to determine whether they can hit their cost-roadmap targets.
- BNEF and GTM Research report U.S. module prices have increased approximately $0.10/W since the beginning of 2017, due to trade case fears.

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, with some analysts expecting prices below $0.3/W and costs below $0.25/W by 2020.

• 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 (08/18/17); Deutsche Bank (09/20/17, 10/03/17); Goldman Sachs (05/09/17); GTM Research (June 2017); IHS Markit, Technology Group, PV Integrated Market Tracker, October, 2017; Navigant Research (03/29/17).
Since Q3 2016, the decrease in inverter price has slowed.

- In Q2 2017, utility and commercial inverter pricing was flat Q/Q, while residential inverter pricing fell 6% over the same period.
- Central and string inverter prices have dropped 46%-57% since Q1 2014.
- As prices have dropped, manufacturers have included new standards and features.
- GTM Research expects price reductions to continue due to the ongoing introduction of high-power string inverters and increasing adoption of 1,500-volt systems.

Source: GTM Research/SEIA “Solar Market Insight Q3 2017.”
• Module-level power electronics (MLPE) price and costs are at historic lows and shipments are at historic highs—companies are expanding into new markets, growing shipments but also growing competition.

• From Q2 ’16 to Q2 ’17, Enphase and SolarEdge MLPE prices fell 14% and 17% respectively.
  – Enphase and SolarEdge MLPE costs also decreased by 14% and 21% respectively over the same period.
  – These companies have also cut operating costs and are transitioning to more advanced technologies to better compete in this highly competitive marketplace.

• In Q2 2017, SolarEdge achieved record shipment levels, growing 32% y/y, propelling them to record levels of revenue (despite continued reduction in price). Enphase shipments rebounded in Q2 2017, growing 9% y/y.
  – Some of the new MLPE products have not achieved significant penetration in the U.S. market yet.

Sources: Enphase/SolarEdge public filings.
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SREC Pricing

SREC pricing in higher-priced markets have decreased $0–$60/MWh in 2017 (0%–23%) and $3–$14/MWh in lower-priced markets.

Stock Market Activity

- Solar stocks made significant gains in 2017—up 33% from the beginning of the year, compared to 14% from the S&P500.
- While public companies in the solar space have performed well in 2017, overall there is wide variety by market segment and company.
  - First Solar and SunPower, which received 83% and 85% of their net sales in 2016 from the U.S. market respectively, and which both produce the majority of their modules abroad, would experience drastically different outcomes if the Section 201 tariffs are put in place in the United States.
  - While Chinese PV manufacturers’ margins have been damped by low pricing, their largest market (China) has experienced larger than expected growth.

Notes: Average market cap. of securities in TAN was $9.8 billion (12/31/16), Russell 2000, $1.6 billion (6/27/16).
Sources: Stock market: Yahoo Finance (07/28/17).
Thank You

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# List of Acronyms and Abbreviations

- **AC**: alternating current  
- **AD**: antidumping duty  
- **ASP**: average selling price  
- **BNEF**: Bloomberg New Energy Finance  
- **CSP**: concentrating solar power  
- **CVD**: countervailing duty  
- **DC**: direct current  
- **DG**: distributed generation  
- **ETF**: exchange traded fund  
- **FIT**: feed-in-tariff  
- **G&A**: general and administrative expenses  
- **GW**: gigawatt  
- **kW**: kilowatt  
- **kWh**: kilowatt-hour  
- **ILR**: inverter loading ratio  
- **LBNL**: Lawrence Berkeley National Laboratory  
- **LSC**: low-cost storage  
- **MFG**: manufacturing  
- **MLPE**: module-level power electronics  
- **MW**: megawatt  
- **MWh**: megawatt-hour  
- **NEM**: net energy metering  
- **O&M**: operation and maintenance  
- **PPA**: power purchase agreement  
- **PURPA**: Public Utility Regulatory Policies Act  
- **Q/Q**: quarter over quarter  
- **ROW**: rest of world  
- **SG&A**: selling, general and administrative expenses  
- **SHS**: solar home system  
- **SREC**: solar renewable energy certificate  
- **TPO**: third-party owned  
- **USITC**: United States International Trade Commission  
- **W**: watt  
- **WACC**: weighted average cost of capital  
- **y/y**: year over year  
- **YTD**: year to date