NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Fall 2021 Solar Industry Update

David Feldman
Robert Margolis

October 20, 2021

NREL/PR-7A40-81325

Executive Summary

Global Solar Deployment

- H1 2021 PV installations increased significantly, y/y, for many leading markets.
  - China installed 13 GW_{DC} in H1 2021.
  - India installed 4.6 GW_{DC} in H1 2021—more than it installed in all of 2020.

U.S. PV Deployment

- The United States installed 7.4 GW_{AC} (10.8 GW_{DC}) of PV in H1 2021—its largest H1 total ever.
- During H2 2020–H1 2021, 11 states generated more than 5% of their electricity from solar, with California leading the way at 24.3%.
- The United States installed approximately 1.9 GWh/0.6 GWAC of energy storage onto the electric grid in H1 2021, up 279% y/y, as a result of record levels of residential and front-of-the-meter deployment (mostly in California).
- As of Q4 2020, over 231,000 U.S. employees spent the majority of their time on solar, with another 86,000 U.S. jobs spending under 50% of time associated with solar.

PV System and Component Pricing

- In 2020, the ranges in average U.S. PV system pricing across methods were reported to be:
  - $2.7/W to $3.7/W for residential
  - $1.4/W to $2.9/W for nonresidential
  - $0.9/W to $1.1/W for utility-scale.
- In 2021, PPAs for U.S. utility-scale PV systems are priced at $20/MWh for projects in CAISO/non-ISO West, and $30-$40/MWh for projects elsewhere in the continental United States.
- At the end of September, the spot price of polysilicon was $31/kg – its highest mark in 10 years. The increased price of polysilicon is driving up wafer/cell/module pricing, however not nearly to the same degree, with prices still below what they were 2 years ago.
- In Q2 2021, U.S. mono c-Si module prices rose $0.01/W, q/q, and were flat y/y—trading at a 59% premium over global ASP.

Global Manufacturing

- In In H1 2021, U.S. c-Si module production dipped 7% y/y, while thin-film (i.e. CdTe) production peaked, increasing 57%, y/y.
  - In H1 2021 c-Si and thin film manufacturing had a utilization rate of 49% and 95%, respectively.
- 13.8 GW of PV modules were imported into the United States in H1 2021, down 3% y/y.
- 1.4 GW_{DC} of cells were also imported in H1 2021, up 11%.

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

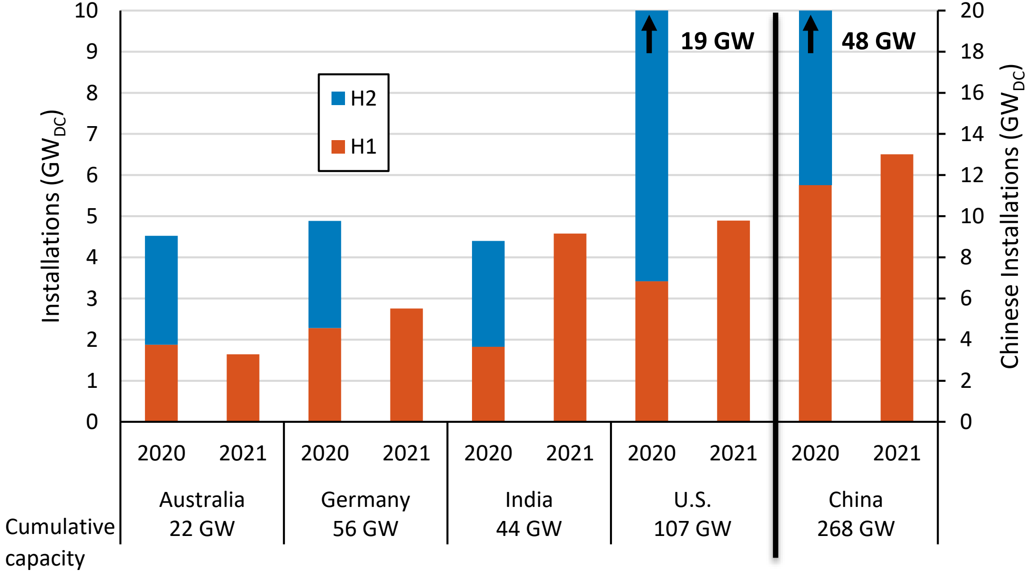
Agenda

1. Global Solar Deployment
2. U.S. PV Deployment
3. PV System Pricing
4. Global Manufacturing
5. Component Pricing
6. Market Activity

ITC Challenges for LMI Customers

- **H1 2021 PV installations increased significantly, y/y, for many leading markets.**
  - China installed 13 GW_{DC} in H1 2021.
  - India installed 4.6 GW_{DC} in H1 2021—more than it installed in all of 2020.
- **In September, the Chilean National Energy Auction announced a CSP world-record low bid of $0.034/kWh, from the 390-MW Likana facility.**
- **The COVID-19 pandemic significantly contracted the sale of off-grid solar products, due to:**
  - Regional lockdowns
  - Logistical and supply chain challenges
  - Hardware pricing increases.

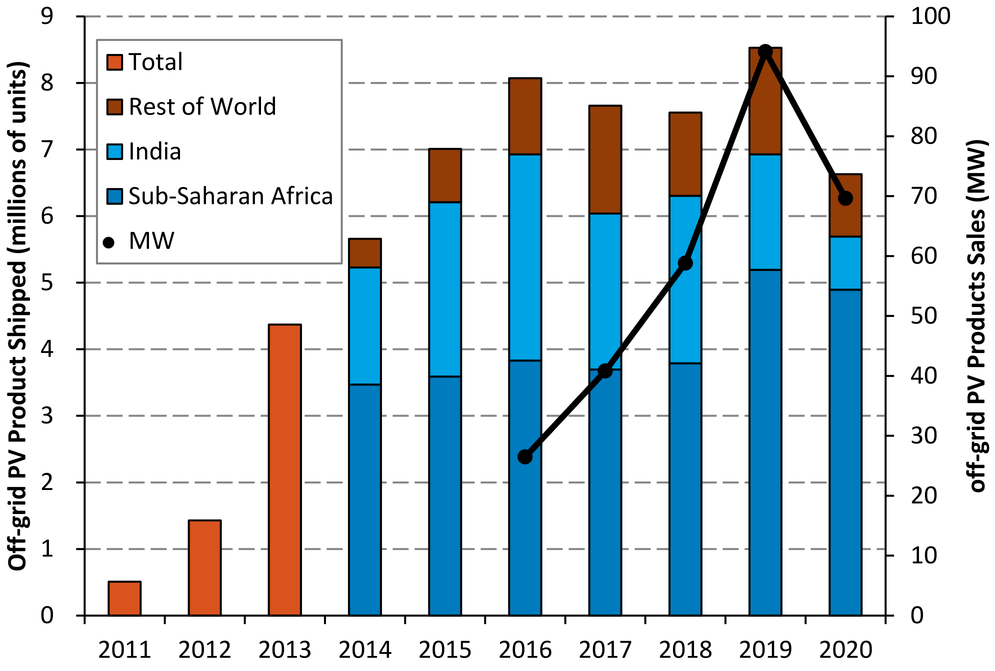
International H1 2021 Installations



- H1 2021 PV installations increased significantly, y/y, for many leading markets.
- India installed more in H1 2021 than it did all of 2020, despite various state-imposed lockdowns.
  - Analysts attributed India's large increase to targeted lockdowns that better enabled developers to manage contingencies.
- Australia's installations are slightly down, y/y, due to reductions in large-scale PV capacity additions, which are more likely to occur in H2. In H1 2021, the country installed 15% more rooftop PV capacity than in H1 2020.
- At the end of June, these countries have cumulatively installed 497 GW_{DC} of PV.

Sources: Australian Photovoltaic Institute. IEA, Snapshot of Global PV Markets: 2021. Mercom (07/26/21 09/06/21). Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q3 2021.

Global Off-Grid Solar Market



- The COVID-19 pandemic significantly contracted the sale of off-grid solar products, due to:
  - Regional lockdowns
  - Logistical and supply chain challenges
  - Hardware pricing increases.
- The Global Off-Grid Lighting Association tracked 6.6 million off-grid solar products, with a capacity of 70 MW, that sold in 2020 for a total of $525 million.
  - Global Off-Grid Lighting Association estimates that it tracks roughly 28% of total off-grid sales, though it varies by product and market.
  - 74% of sales in 2020 were in sub-Saharan Africa (29% from Kenya alone), and 12% were in India.
  - Approximately 67% of the systems installed in 2020 were cash sales; however, cash sales only represented 13% of solar home systems (versus the pay-as-you-go financing model).

Source: Global Off-Grid Lighting Association, “Global Off-Grid Solar Market Report Semi-Annual Sales and Impact Data.”

CSP Updates

- In September, the Chilean National Energy Auction announced a CSP world-record low bid of $0.034/kWh, from the 390-MW Likana facility.
  - The project is to comprise three 130-MW towers with 13 hours of storage.
  - Beyond the great resources of Chile, the record-low bid was partly attributed to the reduction in price of heliostats, which have fallen from around $\$125/m^2$ to $\$80/m^2$ in the past 10 years.
- In October, it was announced that Spain will auction up to 200 MW of new CSP plants by the end of the year.
  - This announcement came as part of a presentation announcing a 3.3-GW auction for PV and wind projects.
- In September, the Chinese provinces announced 500 MW of winning CSP bids, mostly bid in conjunction with PV projects.
- In September, it was announced the world's oldest operating CSP facility, SEGS in the United States, would retire most of its capacity—from 356 MW down to 92 MW.
  - The system, originally made up of nine plants built from 1984-1990, shuttered two plants in 2015 and another six in the summer of 2021, leaving one plant remaining.
- In June and July, several companies (Bloom Energy, Heliogen, Synhelion) announced plans to develop green hydrogen using CSP.
  - Green hydrogen is seen by many as critical in getting to 100% carbon-free energy in applications such as Peakers and jet fuel.

Source: Helioscsp: (10/04/21, 10/01/21, 09/30/21, 09/14/21, 06/23/21, 06/15/21); PVMagazine (09/01/21)

1 Global Solar Deployment

2 **U.S. PV Deployment**

3 PV System Pricing

4 Global Manufacturing

5 Component Pricing

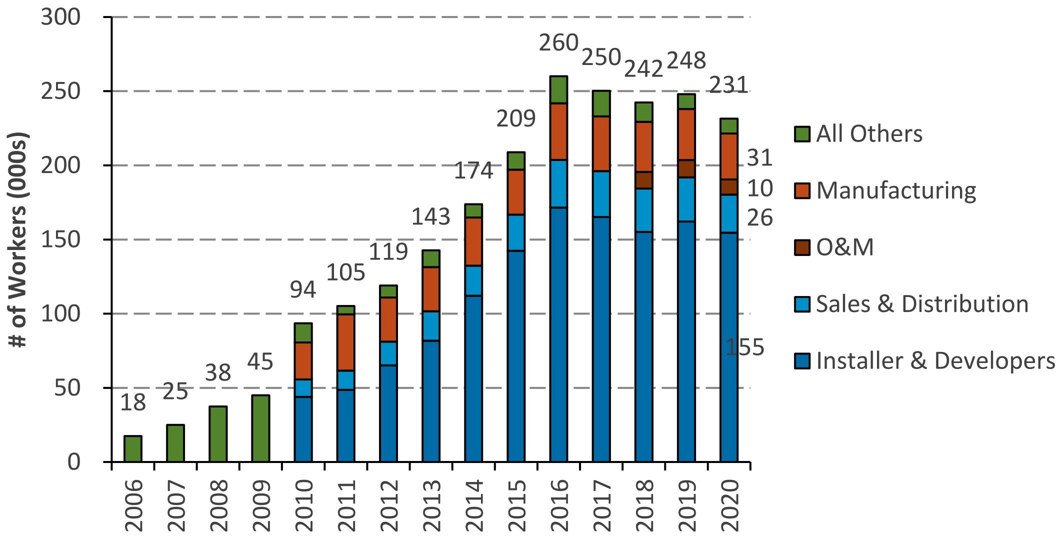
6 Market Activity

ITC Challenges for LMI Customers

- **The United States installed 7.4 GW_{AC} (10.8 GW_{DC}) of PV in H1 2021—its largest H1 total ever.**
- **During H2 2020–H1 2021, 11 states generated more than 5% of their electricity from solar, with California leading the way at 24.3%.**
- **The United States installed approximately 1.9 GWh/0.6 GWAC of energy storage onto the electric grid in H1 2021, up 279% y/y, as a result of record levels of residential and front-of-the-meter deployment (mostly in California).**
- **As of Q4 2020, over 231,000 U.S. employees spent the majority of their time on solar, with another 86,000 U.S. jobs spending under 50% of time associated with solar.**

U.S. Solar Workforce

- As of Q4 2020, over 231,000 U.S. employees spent the majority of their time on solar, with another 86,000 U.S. jobs spending under 50% of time associated with solar.
- From 2016-2020, the U.S. reduced its solar workforce, despite installing more annual capacity per year.



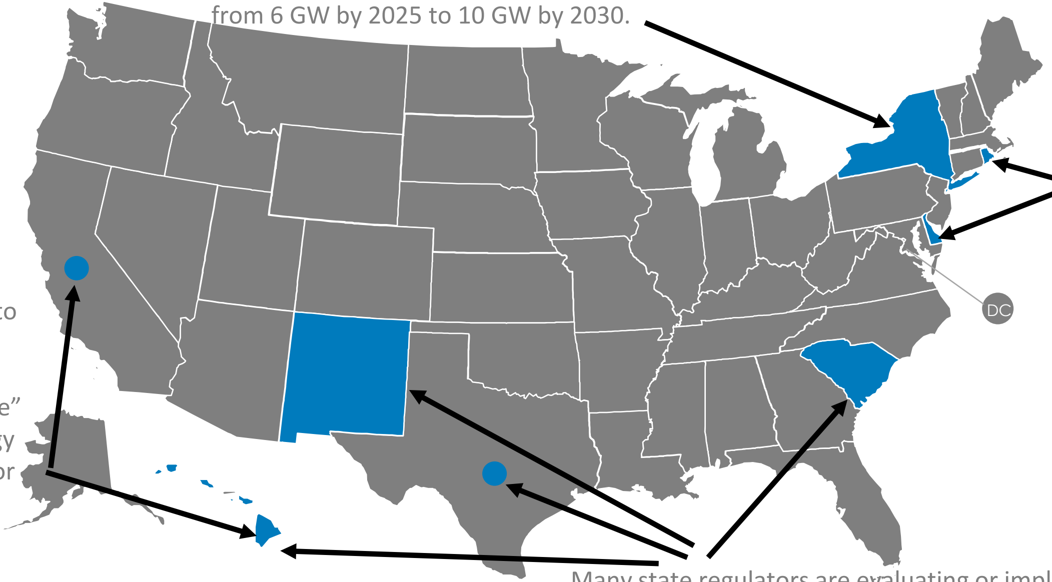
- Over half the solar workforce was involved in construction activities.
  - In 2020, 88% of construction employers reported that it was difficult to hire.
- Despite utility-scale PV representing 68% of solar electricity generation in 2020, only 19% of installation jobs were associated with that sector.
  - Conversely, residential PV only represented 19% of solar electricity generation in 2020 but was associated with almost 55% of solar installation jobs.
- Women are underrepresented within the solar workforce, representing 30%, compared to a national workforce average of 48%.
  - African Americans and people 55 and over are also underrepresented, compared to the national workforce, while solar reports a higher representation than the national average of union members, veterans, and non-African American minorities.

Sources. The Solar Foundation, "The National Solar Jobs Census 2020." May 2021. The Department of Energy The U.S. Energy and Employment Jobs Report

Q2 2021 State Updates

- Many states are working on adopting unique net metering successor policies as they continue to increase size limits and aggregate caps; however, many utility proposals include minimum bills, higher fees, time-of-use rates, and lower export credit rates.
- Community solar continues to expand, but many states are facing challenges achieving LMI participation goals.

In September, New York announced it was increasing its distributed solar program goal from 6 GW by 2025 to 10 GW by 2030.



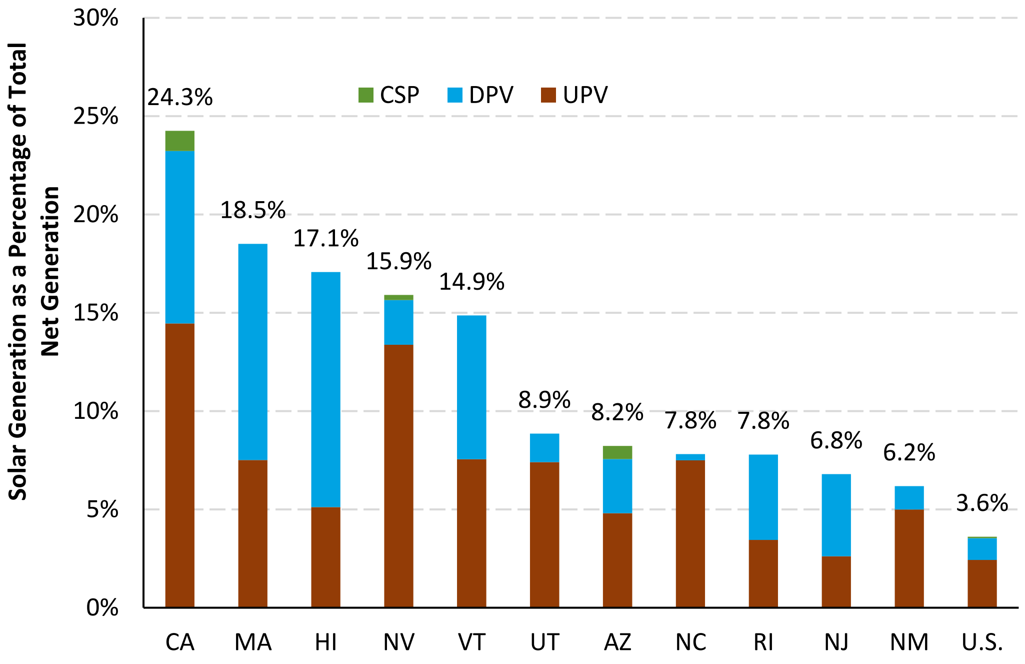
Legislation in Delaware and Rhode Island would require at least 15% and 35% of a community-solar project's capacity to be LMI, respectively. Washington, SMUD, and New York are also working on programs that would encourage LMI for community solar.

Utilities are designing programs to encourage distributed storage. HECO's new program in Hawaii includes a "bring your own device" and would give distributed energy resources economic incentives for allowing the utility to control the device. SMUD, in California, has proposed a "solar and storage rate" as its net metering successor program.

Many state regulators are evaluating or implementing time-of-use (TOU) rates. South Carolina's net-metering successor program includes time-of-use rates, HECO, in Hawaii, is proposing a new program with TOU rates, Pedernales Electric Cooperative (the largest co-op in the United States) is considering TOU rates, and New Mexico approved a new option for residential customers to participate in TOU rates.

Source: Meister Consultants Group, *50 States of Solar: Net Metering Quarterly Update* (Q2 2021)

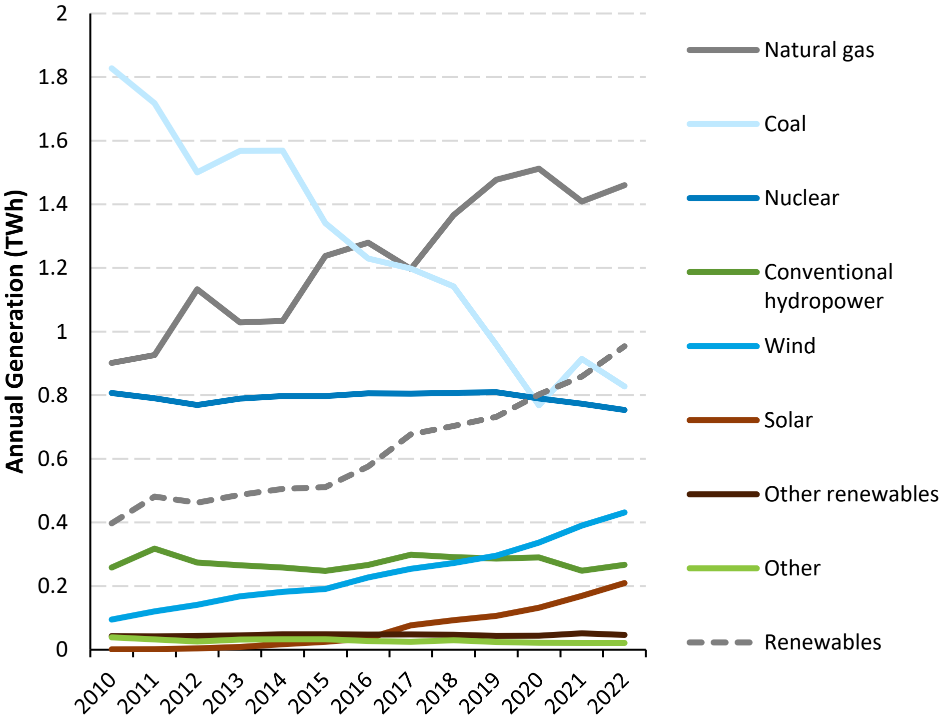
Solar Generation as a Percentage of Total Generation, H2 2019–H1 2020



Note: EIA monthly data for 2020 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.
Source: U.S. Energy Information Administration (EIA), "Electricity Data Browser." Accessed September 22, 2021.

- During H2 2020–H1 2021, 11 states generated more than 5% of their electricity from solar, with California leading the way at 24.3%.
  - Five states generated more than 14% of their electricity using solar.
  - Nationally, 3.6% of electricity was generated from solar, up from 2.9% during the previous 12-month period.
- The role of utility versus distributed solar varies by state, with northeastern states and Hawaii relying more on DPV.

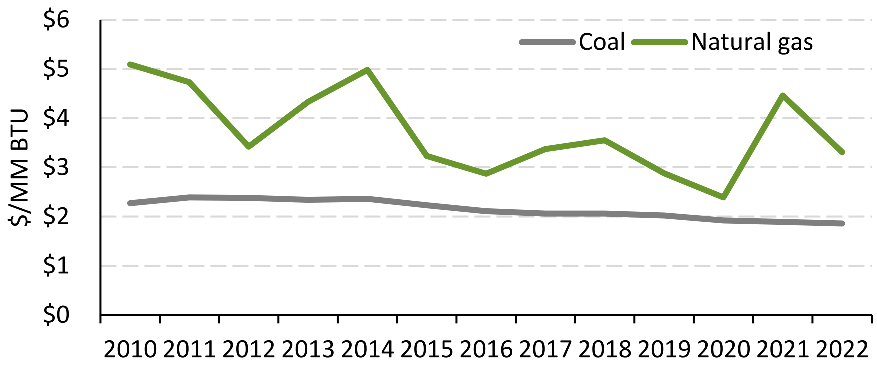
U.S. Electricity Generation by Technology

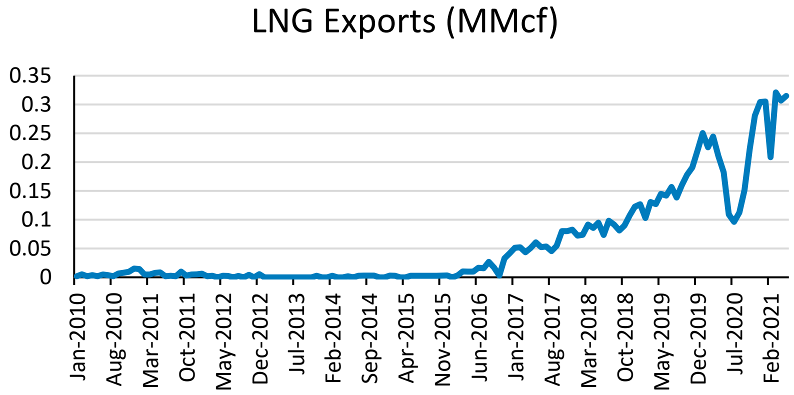


- EIA expects in 2021 electricity generation from natural gas will drop 7% while electricity from coal is expected to increase 19% (pushing it back up above renewables as the #2 source).
  - The projected increase in coal generation, along with increased economic activity, is expected to increase carbon dioxide emissions by 17%. Still, EIA does not expect emissions to return to pre-pandemic levels in the short-term.
- Coal is still well below the levels it was 10 years ago, and the reverse in fortunes is expected to be short-lived as the price of natural gas falls in 2022 and renewables continue to be built.
  - Solar electricity is projected to increase, as a percent of total U.S. electricity generation, from 3.4% in 2020 to 5.2% in 2022, and wind is expected to increase from 8.6% to 10.7%.

Source: EIA, Short Term Energy Outlook, August 2021.

U.S. Coal and Natural Gas Trends



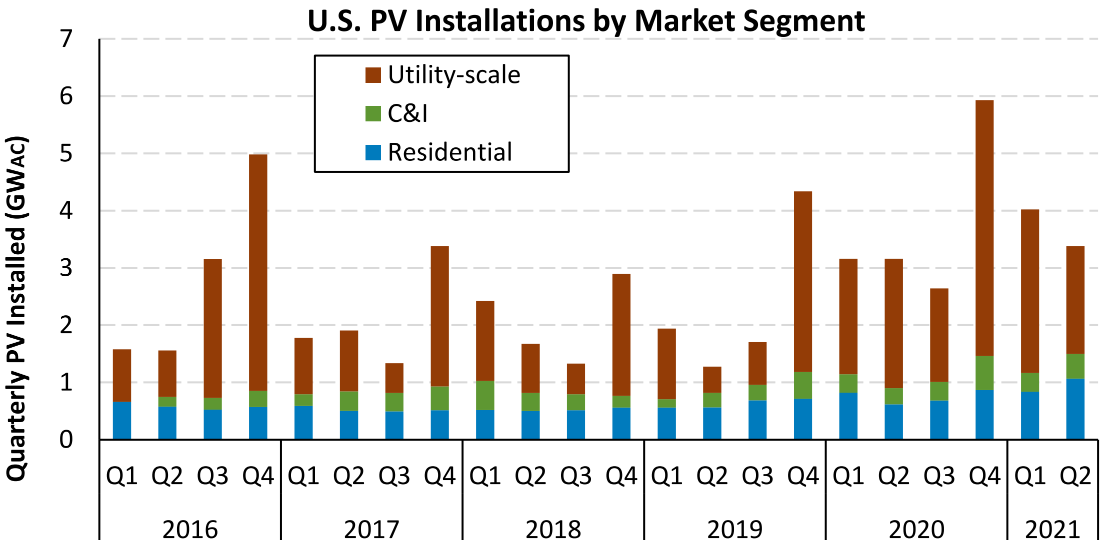


- Cold weather in 2021 caused a significant increase in the U.S. consumption of natural gas while also inhibiting some of its production.
- Additionally, there has been a significant growth in liquified natural gas exports.
  - Natural gas inventories have been drawn down and prices have spiked.
- EIA expects natural gas prices to continue to remain high for the remainder of 2021 with low levels of inventory, before dropping in 2022.
- Historically, coal prices have been relatively stable compared to natural gas. When natural gas price spikes, coal becomes more competitive.

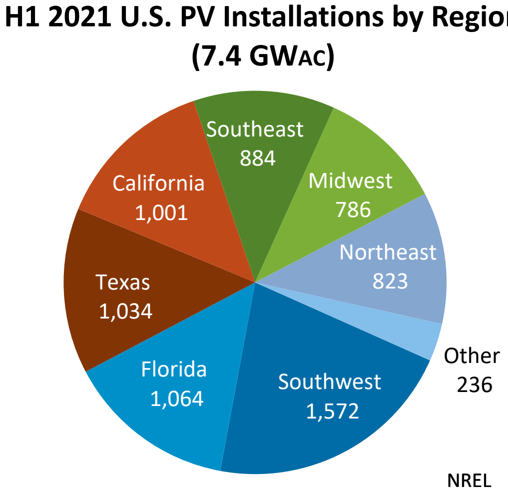
Source: EIA, Short Term Energy Outlook, August 2021.

U.S. Installation Breakdown Annual: EIA (GW_{AC})

- The United States installed 7.4 GW_{AC} of PV in H1 2021, its largest H1 total ever—up 17% y/y.
  - Residential was up 32%, C&I was up 26%, and utility-scale PV was up 11% in H1 2021.



- Texas, Florida, and California installed over 1 GW each, and Nevada added over 600 MW in H1 2021—over half of total installations.
- Despite a concentration of PV installations in the top markets, diversification of growth continues across the United States.
  - Eighteen states installed more than 100 MW_{AC} of PV in H1 2021.



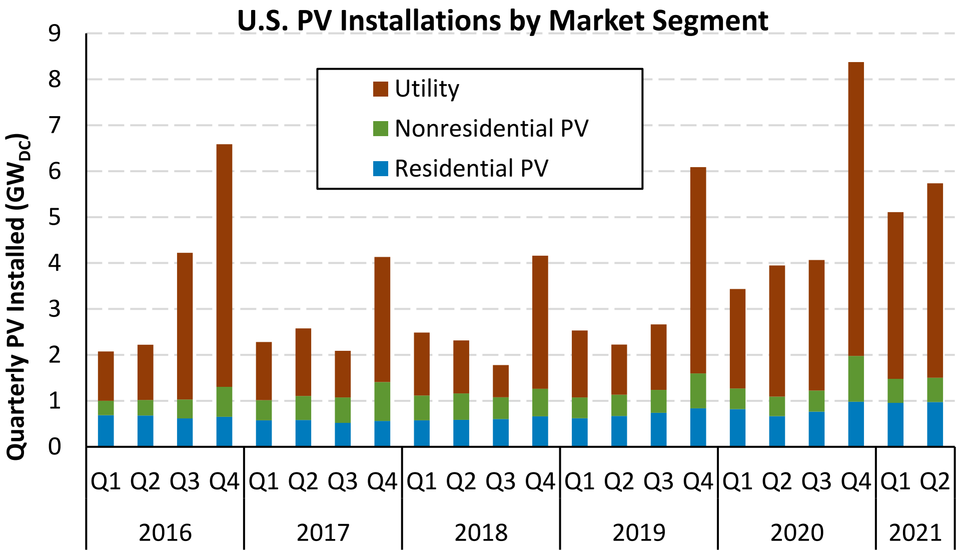
Note: EIA defines "utility-scale" as projects having a capacity greater than 1 MW. EIA reports values in W_{AC} which is standard for utilities. The Solar industry has traditionally reported in W_{DC}. See next slide for values reported in W_{DC}.

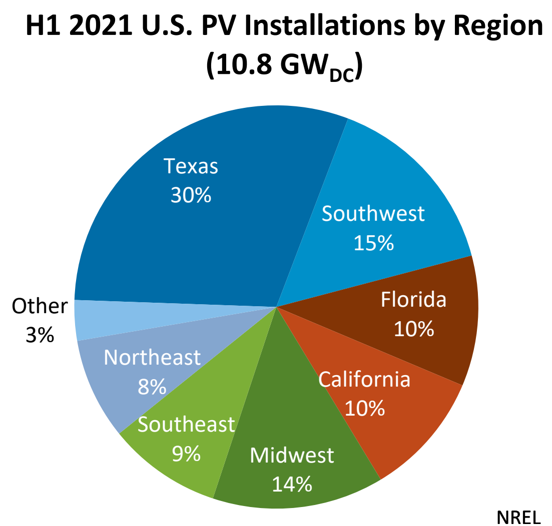
Sources: EIA, "Electric Power Monthly," forms EIA-023, EIA-826, and EIA-861 (August 2021, February 2021, February 2019).

U.S. Installation Breakdown Annual: SEIA (GW_{DC})

Unlike the values on the previous slide, the values on this slide are in GW_{DC} instead of GW_{AC}.

- SEIA reports that the United States installed 10.8 GW_{DC} of PV in H1 2021—up 47% y/y.
- At the end of H1 2021, there were almost 107 GW_{DC} of cumulative PV installations.
- SEIA reports that Texas installed over 3 GW_{DC} of PV in H1 2021, having installed over 1 GW_{DC} of PV in each of the last 5 quarters.

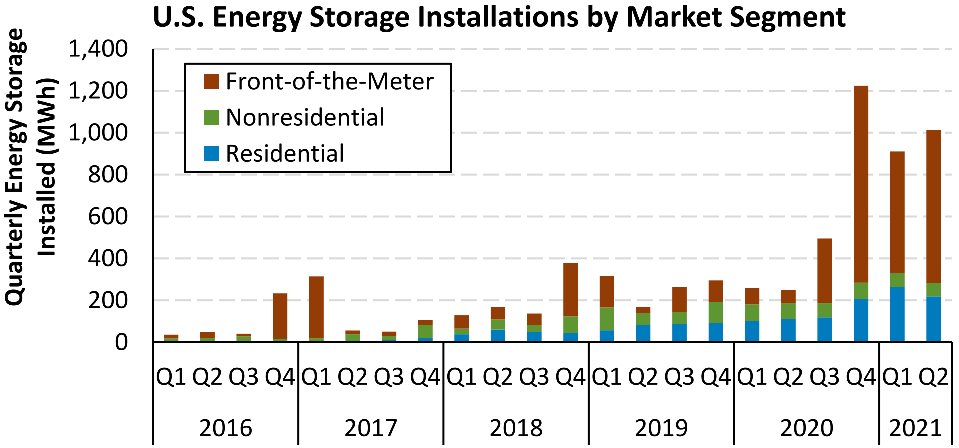


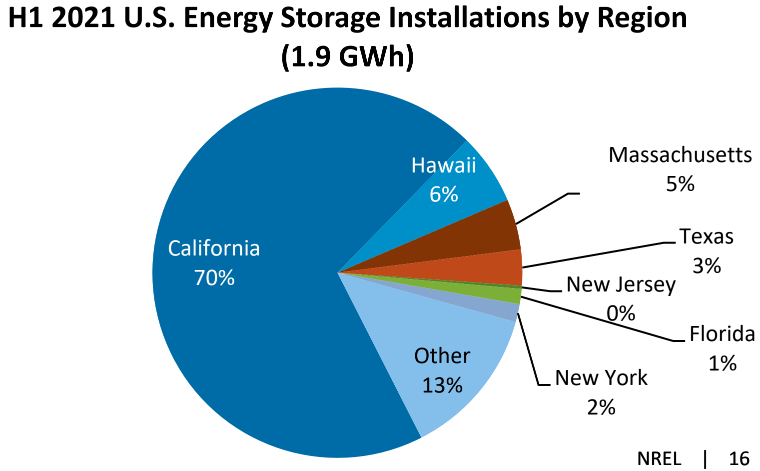


Sources: Wood Mackenzie/SEIA: U.S. Solar Market Insight: Q2 2021.

U.S. Energy Storage Installations by Market Segment

- The United States installed approximately 1.9 GWh/0.6 GW_{AC} of energy storage onto the electric grid in H1 2021, up 279% y/y, as a result of record levels of residential and front-of-the-meter deployment (mostly in California).
  - Five front-of-the-meter installations represented over half of the installs in H1 2021.
  - Q2 2021 was the nonresidential market's biggest quarter since 2019 (in MW), however its lowest level since 2019 in terms of MWh, due to shorter duration systems (2 hours) being installed more frequently.
- The residential market shrank slightly in Q2 2021 due to shortages in Tesla's Powerwall batteries.
- California continued to be far and away the largest residential and utility-scale market in H1 2021, with Massachusetts contributing over half of nonresidential sector capacity, thanks to the SMART program and other policies supportive of community solar-plus-storage.
- Despite the record levels of storage deployment, Wood Mackenzie expects the second half of 2021 to dwarf the first half.

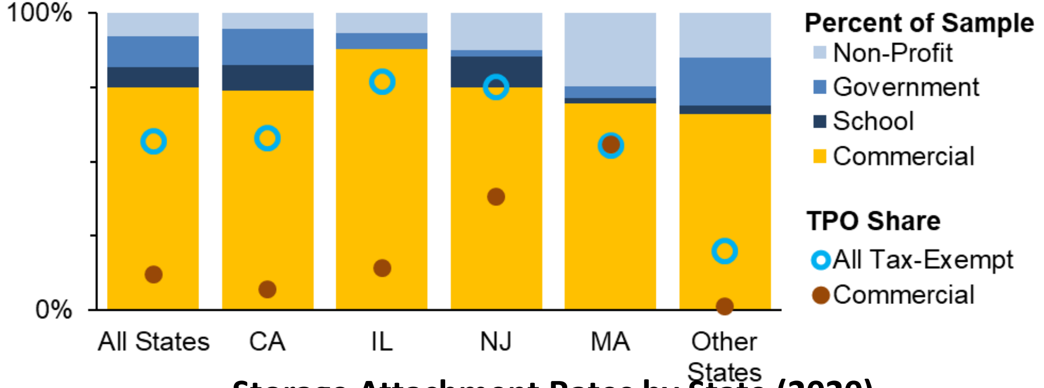




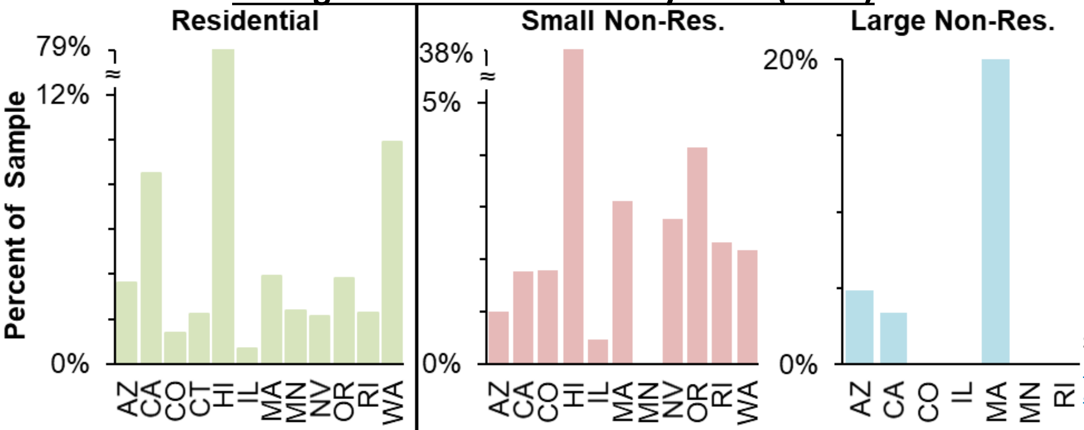
Source: Wood Mackenzie Power & Renewables and Energy Storage Association, "U.S. Energy Storage Monitor."

Five New Things to Know from *Tracking the Sun: 2021 Edition*

Non Res. Customer Segmentation by State (2020)



Storage Attachment Rates by State (2020)



1. The median module efficiency of U.S. residential PV systems was 19.8%, up 0.4 percentage points y/y. A diversity of module technologies are still in use with efficiencies ranging from 16%-22%.

2. MLPE have continued to gain shares across the sample and represent 94% of residential systems, 71% of small nonresidential systems, and 26% of large nonresidential systems installed in 2020.

3. More than 70% of nonresidential sites are hosted by commercial entities, with the remainder consisting of tax-exempt hosts. TPO is considerably more prevalent for tax-exempt entities.

4. Panel orientation has become more varied over time, with 54% of systems installed in 2020 facing south, 24% west, and most of the remainder east.

5. Median storage attachments ranged in 2020 from 3% for nonresidential PV systems to 8% for residential system. The median varies widely by state, with California around 8% and Hawaii around 79% for residential PV systems.

Source: Barbose, G., N. Darghouth, E. O'Shaughnessy, and S. Forrester. 2021. *Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory. September 2021.

Five New Things to Know from Utility-Scale Solar: *2021 Edition*

1. Despite lower average solar resource levels, as U.S. solar deployment has expanded into less sunny places, average capacity factor has been relatively stable; this can be attributed to the increased use of tracking and higher ILRs (Chart 1).

2. Average O&M costs for the cumulative sample have declined from about $32/kW$_{AC}$-year in 2011 to about $16/kW$_{AC}$-year 2020.

3. Weather-normalized fleet-wide performance decline appears to be running at ~1.2%/year on average (Chart 2), higher than the often cited 0.5%-0.8%/year. This number includes model degradation and balance of plant degradation, soiling, and downtime (including curtailment).

4. Tracking boosts net-capacity factors by up to 5% in high-insolation regions.

5. Using reported average capacity factor, O&M, and CAPEX, the authors calculate LCOE, which has fallen by 85% (or 17% annually) since 2010, to $34/MWh (without the ITC).

Chart 1. Average Capacity Factor in 2020 by Project Vintage

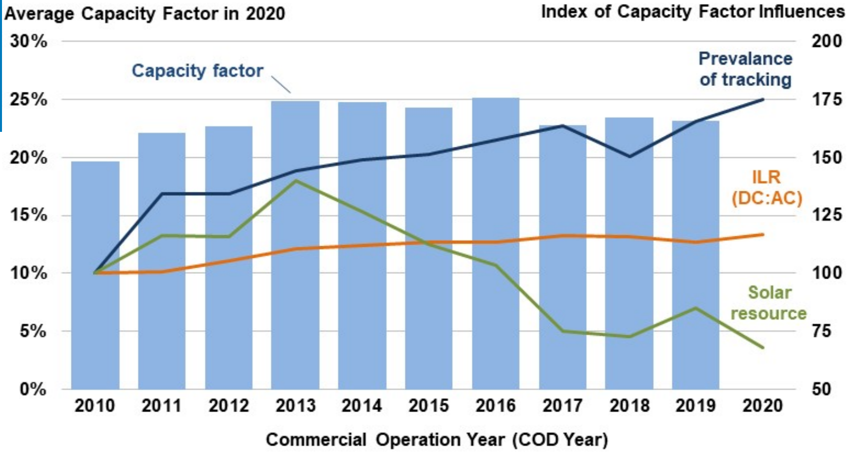
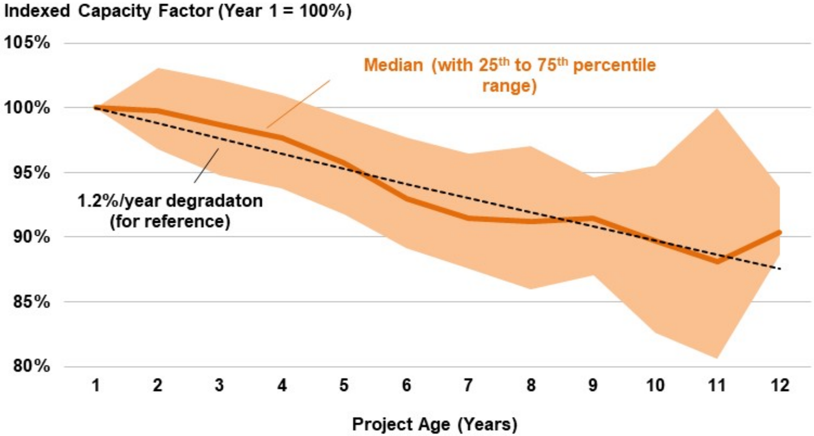


Chart 2. Fleet-Wide Performance Decline as Projects Age



Source: Bolinger, M., J. Seel, C. Warner and D. Robson. 2021. *Solar Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States: 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory

1 Global Solar Deployment

2 U.S. PV Deployment

3 **PV System Pricing**

4 Global Manufacturing

5 Component Pricing

6 Market Activity

ITC Challenges for LMI Customers

- **In 2020, the ranges in average U.S. PV system pricing across methods were reported to be:**
  - $2.7/W to $3.7/W for residential
  - $1.4/W to $2.9/W for nonresidential
  - $0.9/W to $1.1/W for utility-scale.
- **In the first half of 2021, the ranges in average U.S. PV system pricing across a *smaller set of* methods were reported to be:**
  - $2.7/W to $3.9/W for residential
  - $1.6/W to $2.5/W for nonresidential
  - $0.9/W to $1.9/W for utility-scale.
- **In 2021, PPAs for U.S. utility-scale PV systems are priced at $20/MWh for projects in CAISO/non-ISO West, and $30-$40/MWh for projects elsewhere in the continental U.S.**

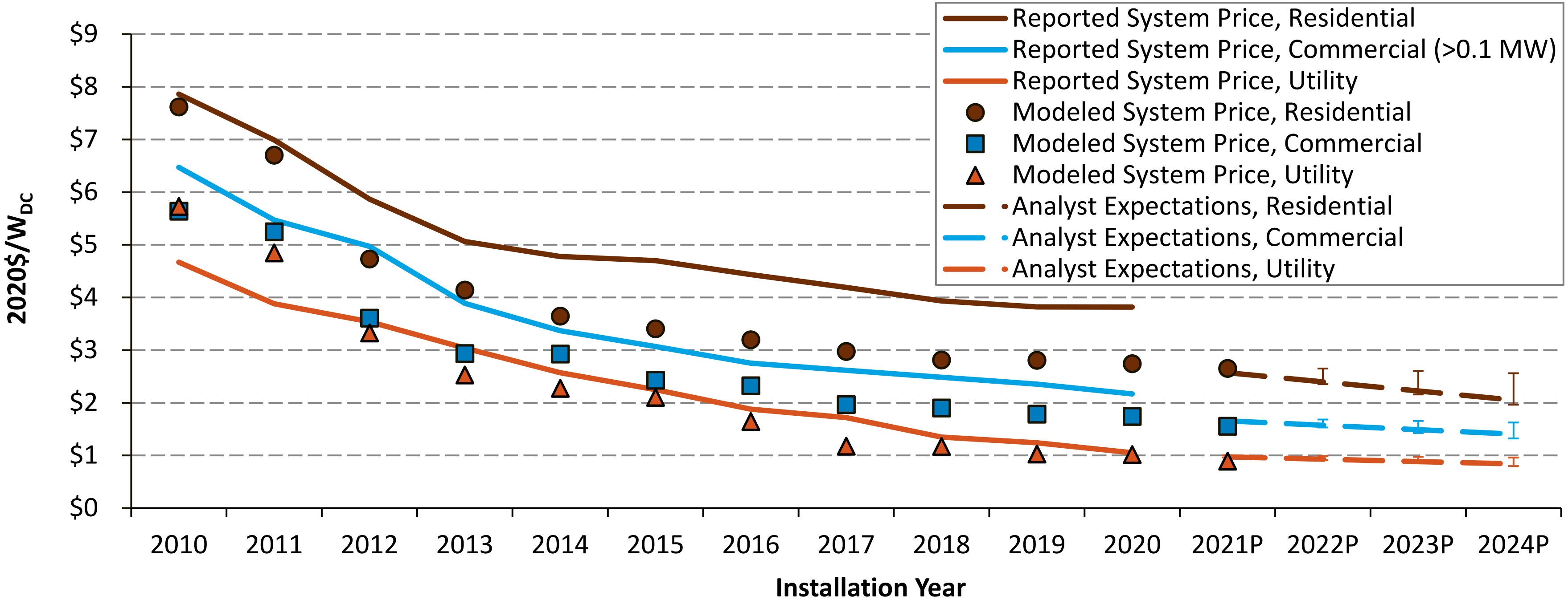
U.S. PV System Pricing

- Most data suggest that PV system pricing across market segments continues its downward trajectory.
- U.S. PV system pricing, or costs, is estimated and quoted in a variety of ways, 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 2020, the ranges in average U.S. PV system pricing across methods were reported to be:
  - $2.7/W to $3.7/W for residential
  - $1.4/W to $2.9/W for nonresidential
  - $0.9/W to $1.1/W for utility-scale.
- In the first half of 2021, the ranges in average U.S. PV system pricing across a *smaller set of* methods were reported to be:
  - $2.7/W to $3.9/W for residential
  - $1.6/W to $2.5/W for nonresidential
  - $0.9/W to $1.9/W for utility-scale.

Reported, Bottom-Up, and Analyst-Projected Average U.S. PV System Prices over Time

Historically, reported pricing and modeled benchmarks have had similar results; however, residential PV system price estimates have diverged over time.

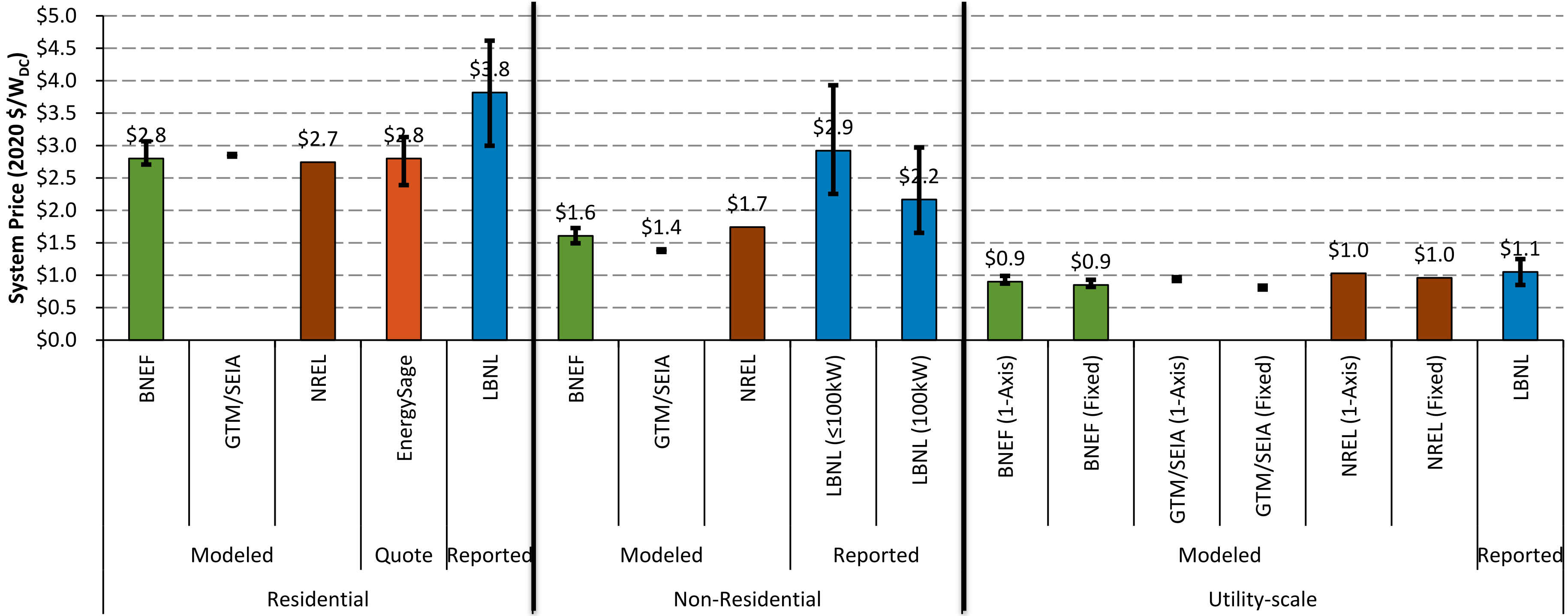
All methodologies show a downward trend in PV system pricing.



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 et al. 2021); reported utility system prices (Bolinger et al. 2021); modeled system prices (Ramasamy et al. 2021); analyst expectations (NREL 2021 Annual Technology Baseline).

2020 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, with quotes being in the middle.

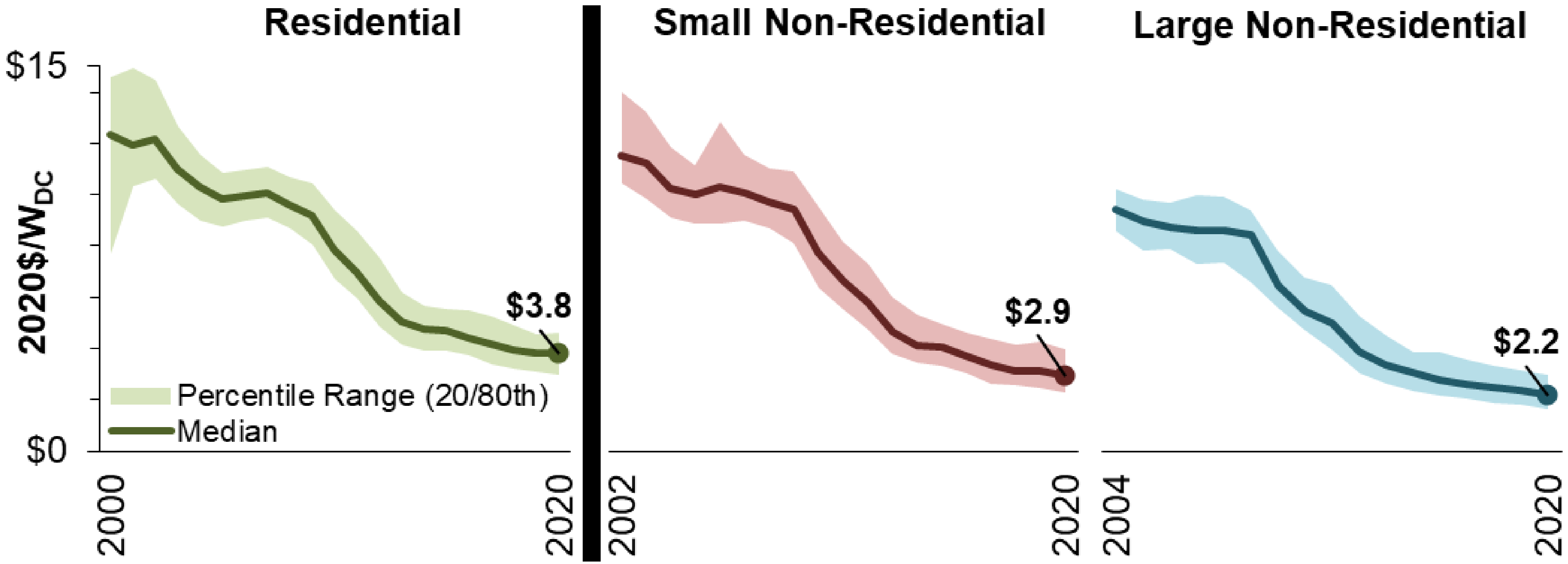


Note: Some sources only report a range, which is represented by the error bars.

Sources: Barbose et al. 2021; Bolinger et al. 2021; Ramasamy et al. 2021; BNEF, "H2 2021 U.S. PV Market Outlook," October 2021; Wood Mackenzie Power & Renewables and SEIA, "U.S. Solar Market Insight 2020 year-in-review," March 2021; EnergySage, "Solar Market place Intel Report H1 2020 – H2 2020.".

Tracking the Sun: National Price, 2000-2020

- Over the last year of the analysis period (2019-2020), median U.S. prices for residential systems remained effectively flat at $3.8/W, while falling by $0.2/W for both small and large nonresidential systems.

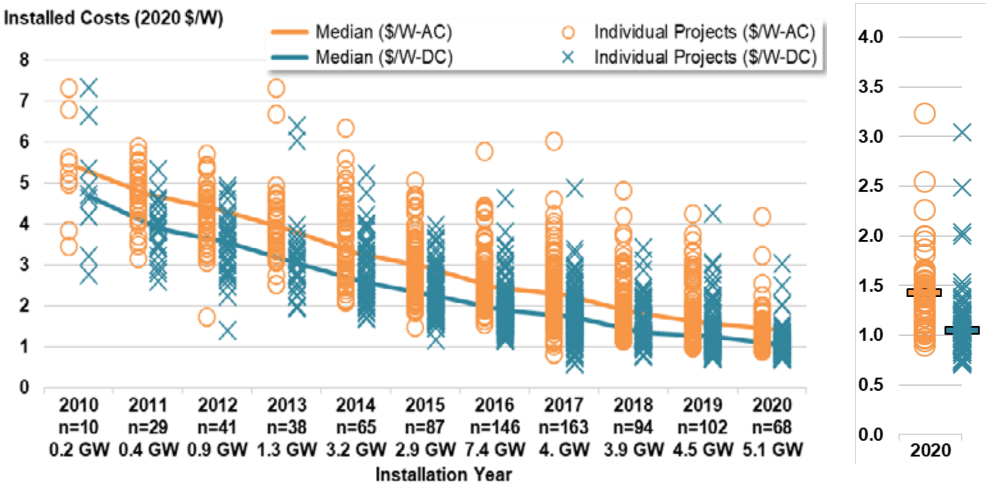


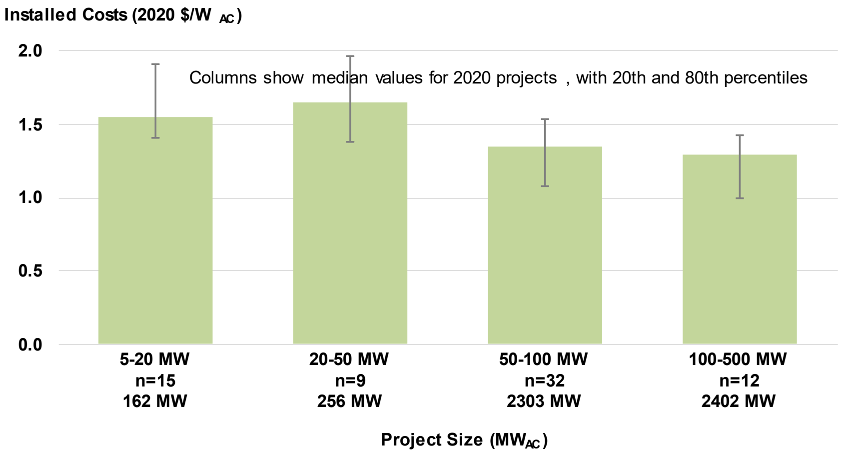
Source: Barbose, G., N. Darghouth, E. O'Shaughnessy, and S. Forrester. 2021. *Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory. September 2021.

Reported Price of U.S. Utility-Scale PV Projects Over Time

- The median installed price of PV has fallen by 74% since 2010 to $1.42/WAC ($1.05/WDC) in 2020.
- The lowest 20th percentile of project prices fell below $1.1/WAC ($0.9/WDC) in 2020, with the lowest project costing $0.7/WDC.

- Economies of scale are evident in the 2019 project cost data, with the median price of systems which were 100–500 MW in size 17% lower than the median price of PV systems, which were 5–20 MW in size.
- This sample is backward-looking and may not reflect the price of projects built in 2020 and 2021.

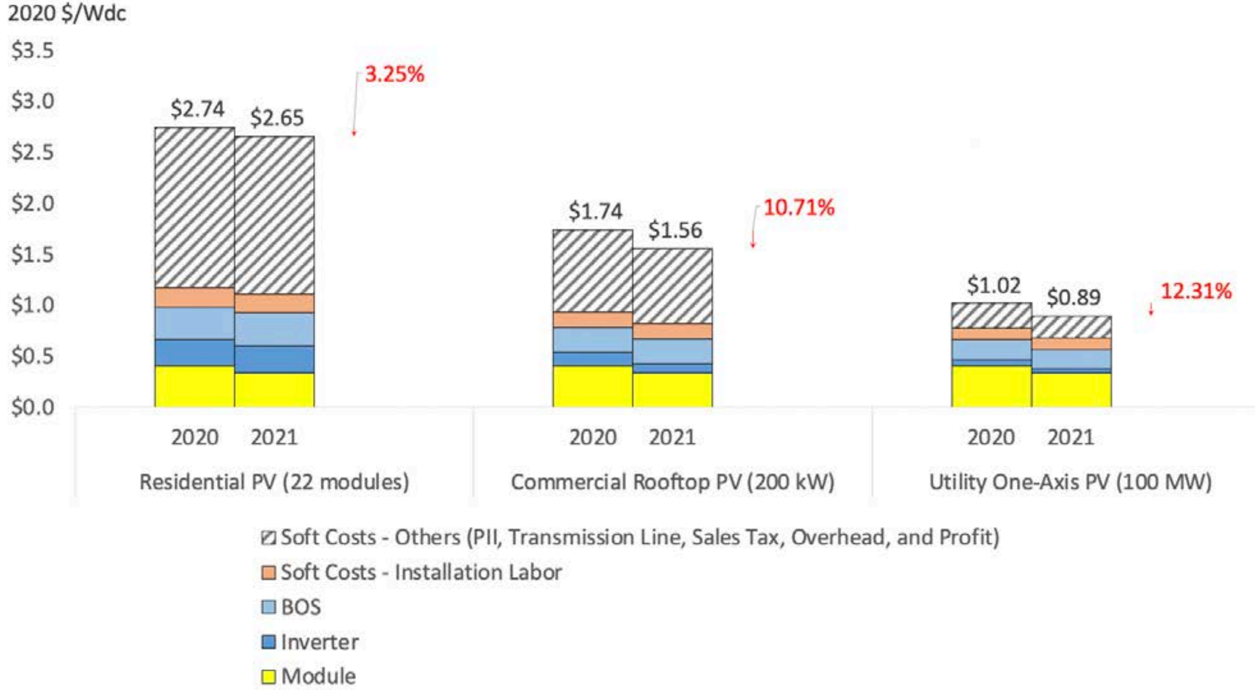




Source: Bolinger, M., J. Seel, C. Warner and D. Robson. 2021. *Solar Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States: 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory1

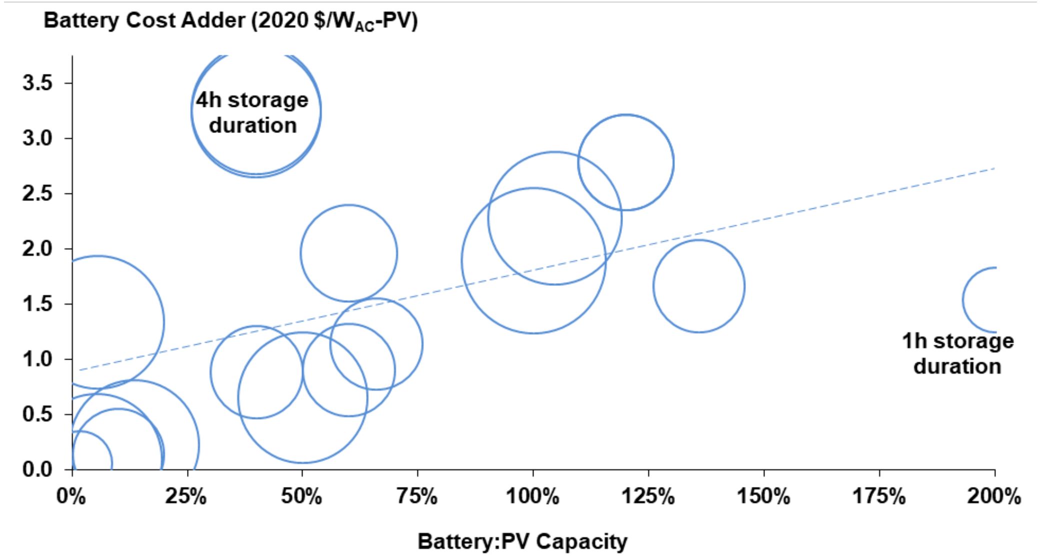
Bottom-Up Modeled System Price of PV Systems by Sector, 2020–2021

- Balance-of-system (BOS) costs have either increased or remained flat across sectors, year-on-year, unlike in previous benchmarking reports, which generally have reported declining BOS costs.
- The increase in BOS cost has been offset by a 17% reduction in module cost.



Source: Ramasamy Vignesh, and David Feldman. 2021. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2021. Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-80694. https://www.nrel.gov/docs/fy21osti/80694.pdf.

Reported Price of U.S. Utility-Scale PV + Storage Projects



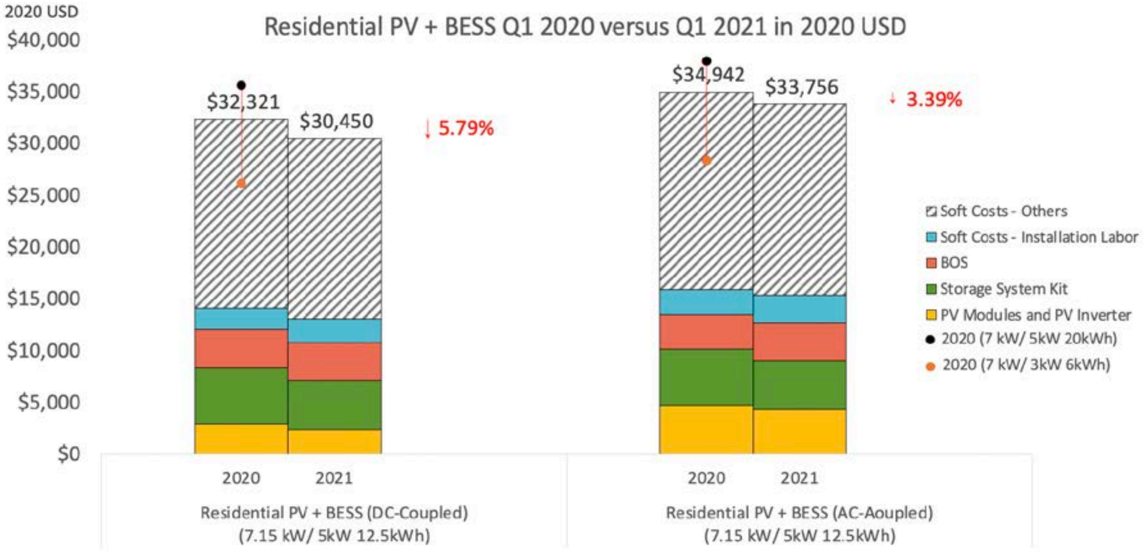
- LBNL also collected pricing data from a sample of PV+battery hybrid systems, which includes 18 projects totaling 180 MWAC of PV, 116 MWAC of battery capacity, and 392 MWh of battery energy, which began operating between 2017-2019.

- The median reported battery costs among 11 projects with a 2019 installation date was $1,100/kWh, representing a median cost adder of $1.54/WAC-PV, or 48% of overall hybrid project installed costs.

Source: Bolinger, M., J. Seel, C. Warner and D. Robson. 2021. *Solar Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States: 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory1

Bottom-Up Modeled Residential System Price of PV+Storage Systems by Sector, 2020–2021

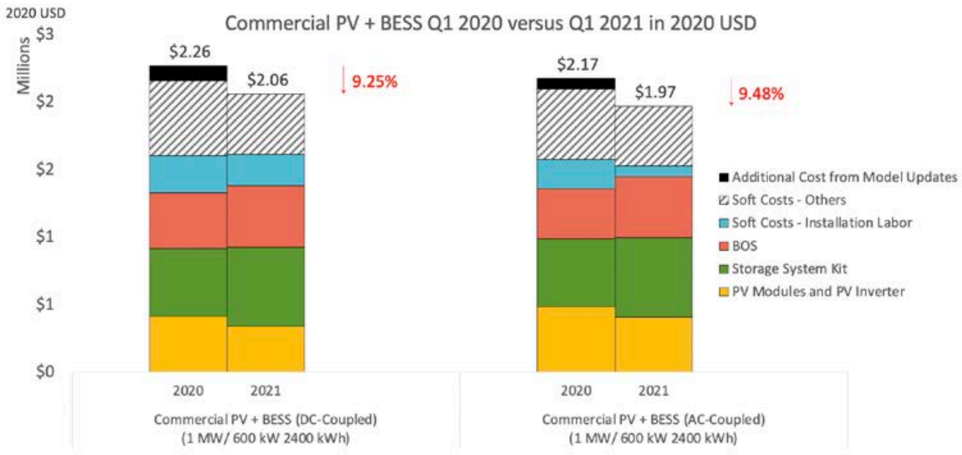
- The CAPEX of PV+storage systems fell between 3%-6% between 2020 and 2021.
  - Most of these reductions can be attributed to reductions in the cost of PV modules and battery pack.

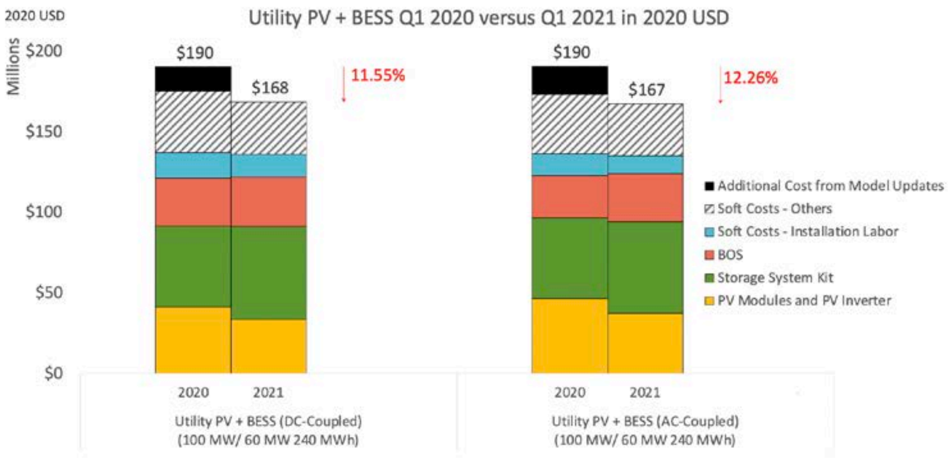


Source: Ramasamy Vignesh, and David Feldman. 2021. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2021. Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-80694. https://www.nrel.gov/docs/fy21osti/80694.pdf.

Bottom-Up Modeled System Price of Commercial and Utility-Scale PV+Storage Systems by Sector, 2020–2021

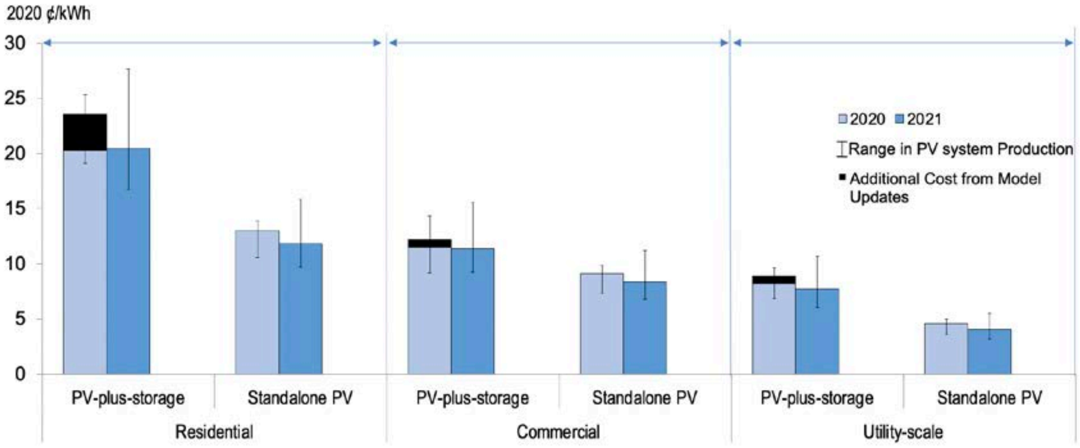
- The CAPEX of PV+storage systems fell between 9%-12% between 2020 and 2021.
  - Most of these reductions can be attributed to reductions in the cost of PV modules and battery pack.





Note: NREL uses different battery sizes this year compared to last year's report, so they adjusted last year's costs for comparison purposes.
Source: Ramasamy Vignesh, and David Feldman. 2021. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2021. Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-80694. https://www.nrel.gov/docs/fy21osti/80694.pdf.

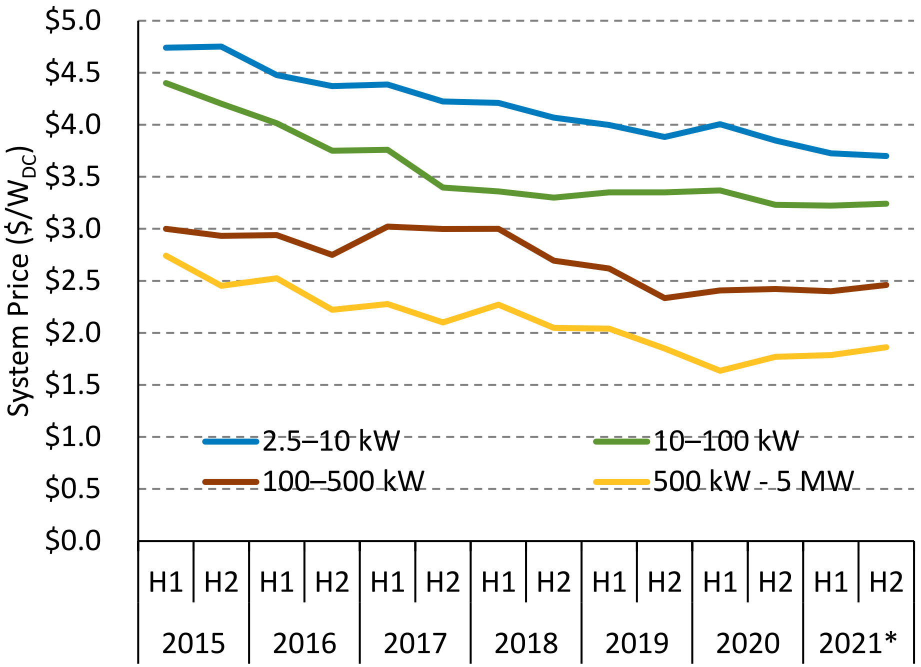
Bottom-Up Modeled LCOE of PV Systems by Sector, 2020-2021



- From 2020 to 2021, residential PV-plus-storage LCOE fell 13%, and residential stand-alone-PV LCOE fell 9%; there were 7% and 13% reductions in levelized electricity costs for commercial and utility-scale PV-plus-storage systems, respectively. At the same time, LCOE of commercial and utility scale PV systems fell by 9% and 12%, respectively.
  - The LCOE of utility-scale stand-alone PV fell from 4.6 cents/kWh in Q1 2020 to 4.1 cents/kWh in Q1 2021.
  - The LCOE of utility-scale PV-plus-storage fell from 8.9 cents/kWh in Q1 2020 to 7.7 cents/kWh in Q1 2021.

Note: NREL uses different battery sizes this year compared to last year's report, so they adjusted last year's costs for comparison purposes.
Source: Ramasamy Vignesh, and David Feldman. 2021. U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks: Q1 2021. Golden, CO: National Renewable Energy Laboratory. NREL/TP-7A40-80694. https://www.nrel.gov/docs/fy21osti/80694.pdf.

System Pricing From Select States



- The upward pressure in material costs appears to be driving prices upward, with larger systems more affected.
  - Larger systems are more likely to have smaller margins and so are less able to absorb an increase in equipment costs.
- From H2 2020 to H2 2021, the median-reported PV system price in Arizona, California, Connecticut, Massachusetts, and New York:
  - Fell 3% to $3.70/W for systems from 2.5 kW to 10 kW
  - Was flat at $3.24/W for systems from 10 kW to 100 kW
  - Increased 2% to $2.46/W for systems from 100 kW to 500 kW
  - Increased 14% to $1.86/W for systems from 500 kW to 5 MW.

2021 YTD MW: AZ (80), CA (281), CT (2), MA (125), NY (300)

- **YTD**

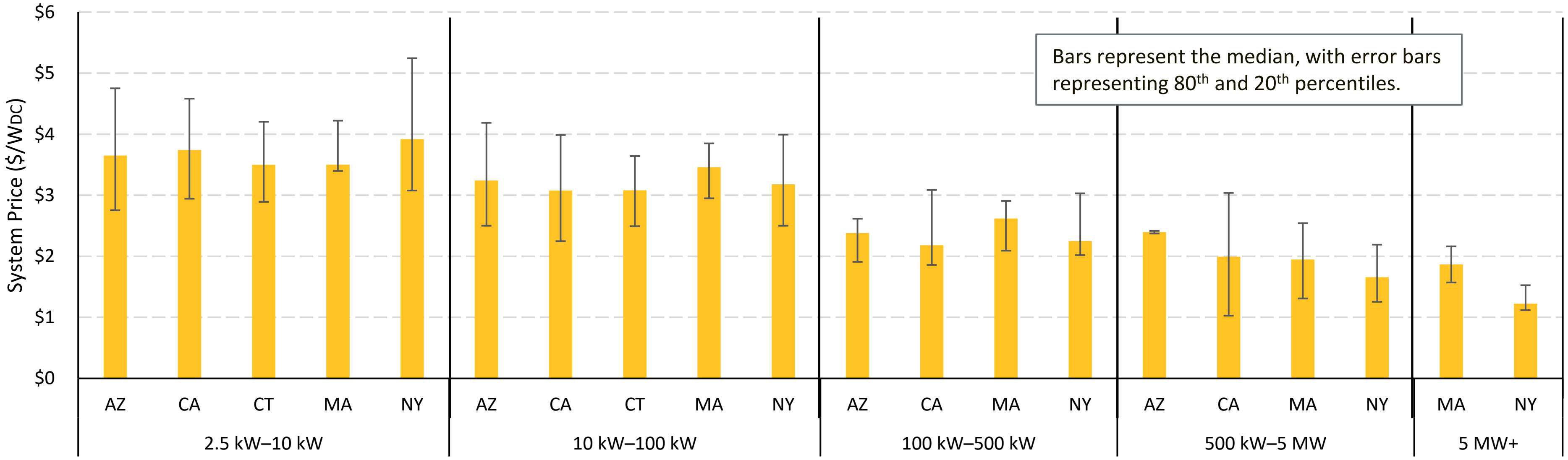
Note: System prices above $10/W and below $0.75/W were removed from the data set. There were not enough reported prices for systems above 5 MW in this data set to show a trend over time.

Sources: AZ (09/27/21), CA NEM database (07/31/21); CT (05/14/21), MA SREC (09/01/21) and SMART (09/01/21) programs; NYSERDA (09/27/21).

System Pricing from Select States, H1 2021

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

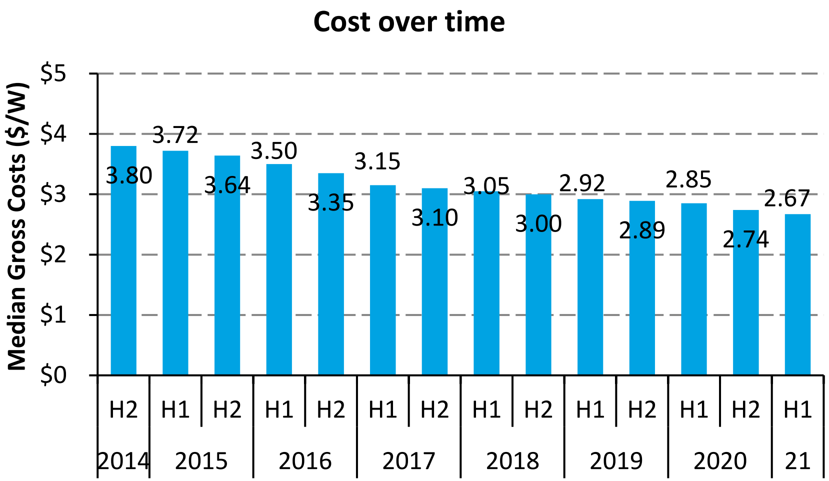
- The median price of a large system in New York was about 34% less than the median price in Massachusetts.
- In 2020, the 20th and 80th percentile prices in New York for a small system were \$3.92/W and \$5.24/W respectively.

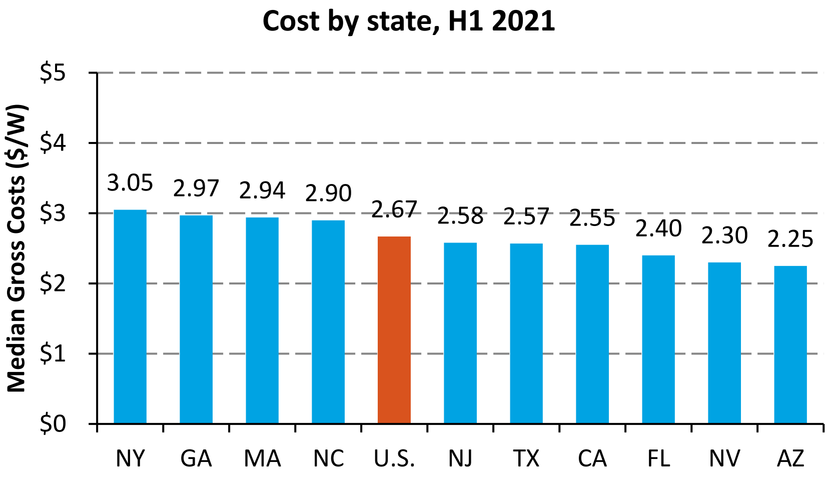


2021 YTD MW: AZ (80), CA (281), CT (2), MA (125), NY (300)
Note: System prices above \$10/W and below \$0.75/W were removed from the data set. There were not enough reported prices for systems above 5 MW in this data set to show a trend over time.
Sources: AZ (09/27/21), CA NEM database (07/31/21); CT (05/14/21), MA SREC (09/01/21) and SMART (09/01/21) programs; NYSERDA (09/27/21).

Residential System Price Reported by EnergySage, H1 2021

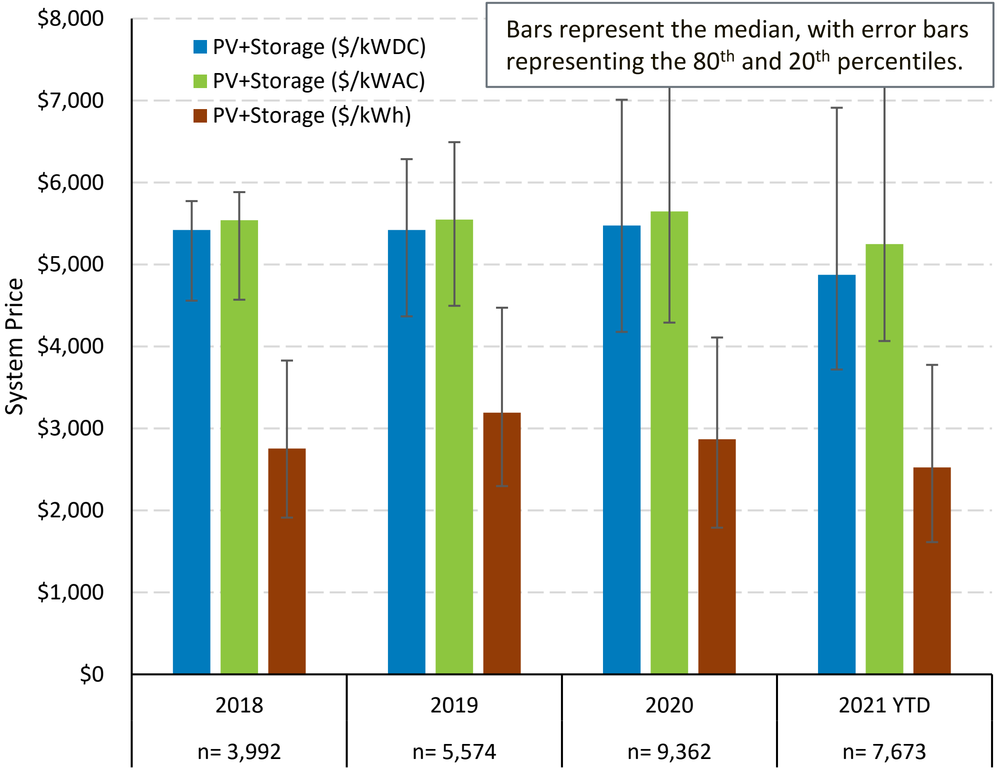
- The median reported price by EnergySage for residential PV systems decreased 6.3% between H1 2020 and H1 2021—the largest decrease since 2017.
  - Unlike previous reductions, this is not tied to an increase in median system size, which was flat.
- Residential system price varied by state. In H1 2021, the median price of a residential system in New York was 36% higher than the median price of a residential system in Arizona.
  - Part of the price disparity between states is due to differences in average system size, though other factors, such as cost of living (e.g., California), also play a role.





Note: price based on winning quoted price.
Source: EnergySage, "Solar Market place Intel Report H2 2020 – H1 2021."

Residential U.S. Storage Pricing



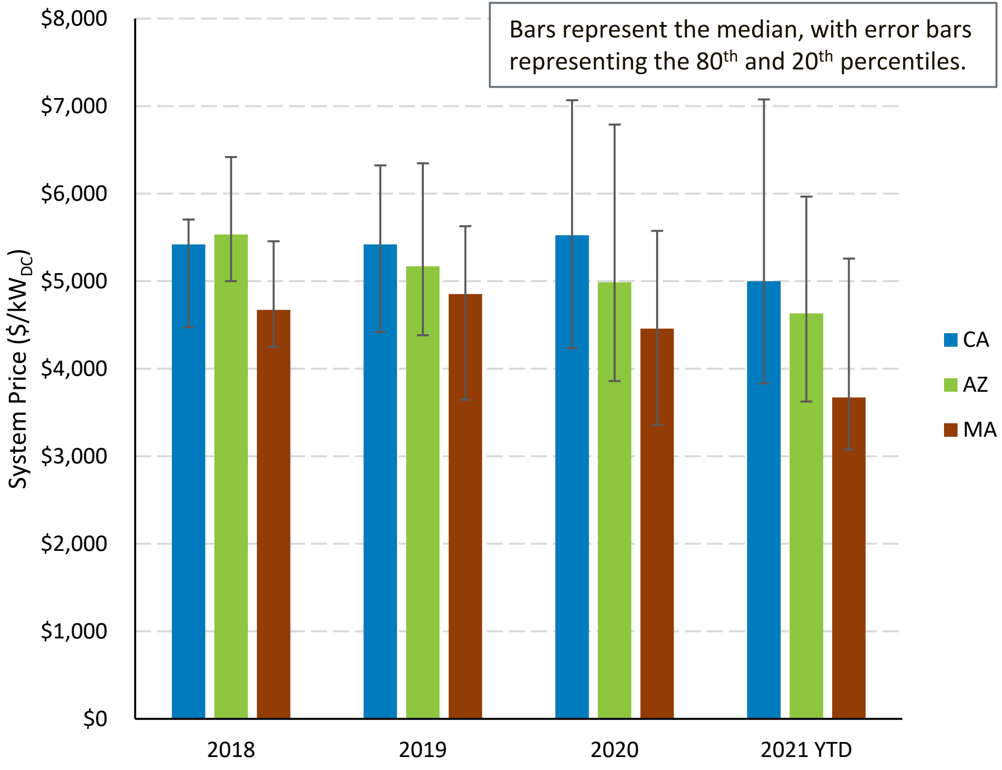
In 2021 YTD, residential PV+storage systems in Arizona, California, and Massachusetts had a median system price of $2,500/kWh, or $5,200/kW_{AC}$ ($4,900/kW_{DC}$)—a reduction of 7%–11% compared to full 2020 median values.

- Most of these systems offer 2–3 hours of storage.
- Units represent total system price divided by the capacity of the battery (kWh) or the capacity of the PV system (kW).

2021 YTD MW: AZ (4), CA (62), MA (96)

Sources: Arizona Goes Solar (09/27/21); CA NEM database (07/31/21); Massachusetts SMART program (09/01/21)

Residential U.S. Storage Pricing



In 2021 YTD, residential PV+storage systems in Arizona, California, and Massachusetts varied between states and internally.

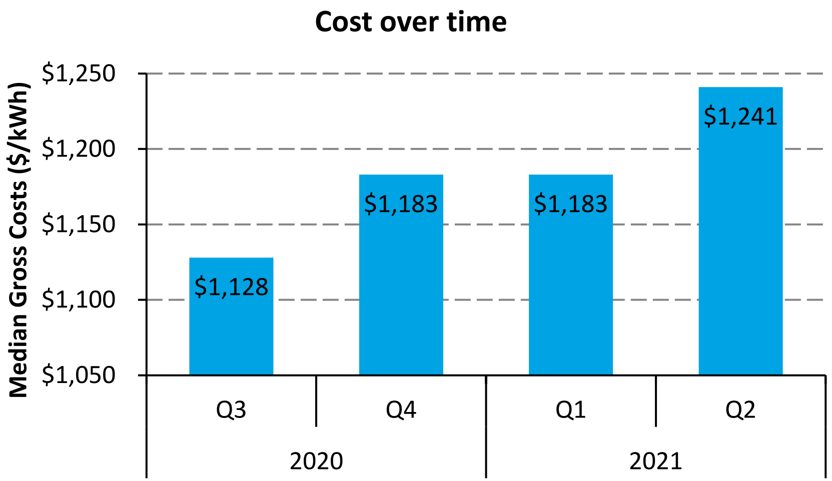
– Prices may vary due to differences in storage power and capacity, permitting and interconnection differences, local competitive factors, and installer experience.

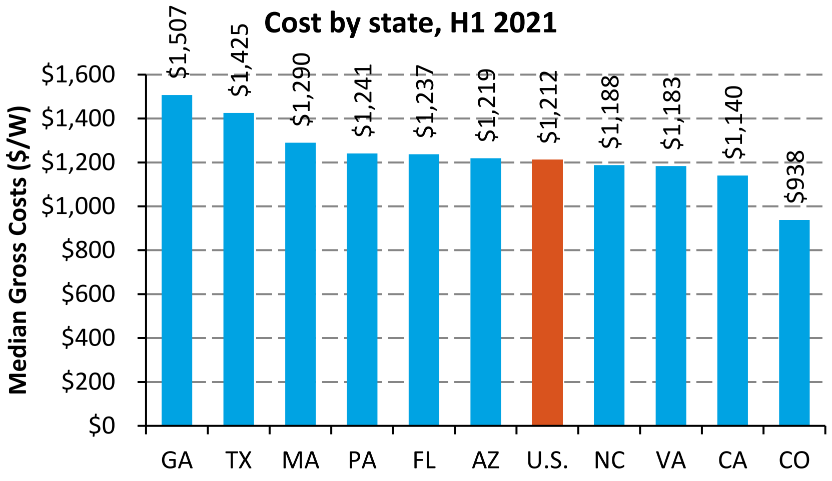
2021 YTD MW: AZ (4), CA (62), MA (96)

Sources: Arizona Goes Solar (09/27/21); CA NEM database (07/31/21); Massachusetts SMART program (09/01/21)

Residential Storage Price Reported by EnergySage, H1 2021

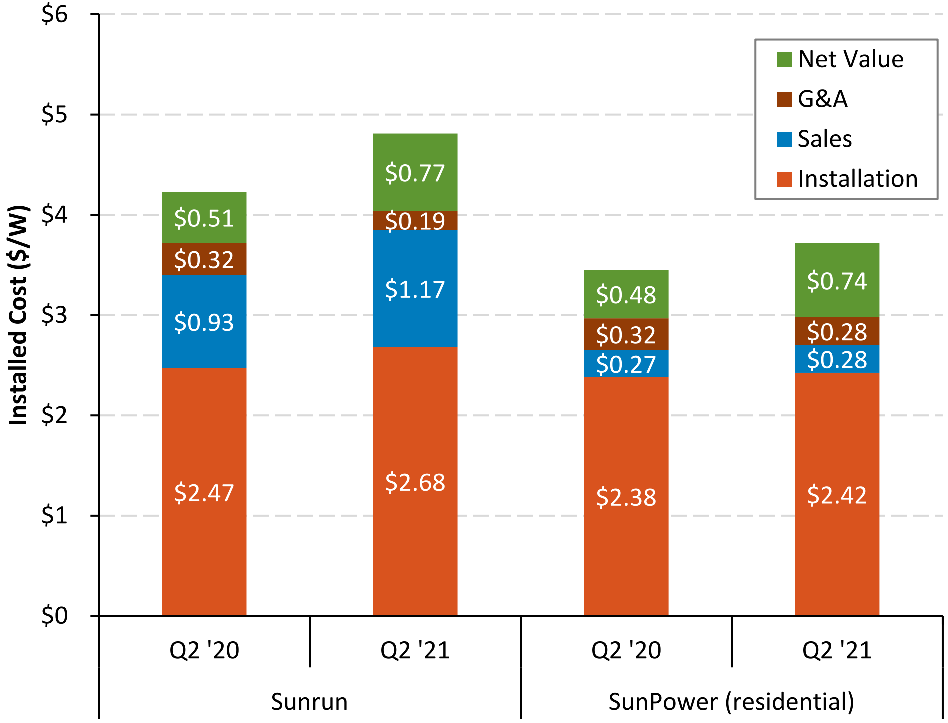
- Unlike solar, EnergySage reports an increase in storage costs over time.
  - Many of the increases in state price medians are correlated to a decrease in median system size.
- Residential storage system price varied by state. In H1 2021, the median price of a residential storage system in Georgia was 60% higher than the median price of a residential storage system in Colorado.





Note: price based on winning quoted price.
Source: EnergySage, "Solar Market place Intel Report H2 2020 – H1 2021."

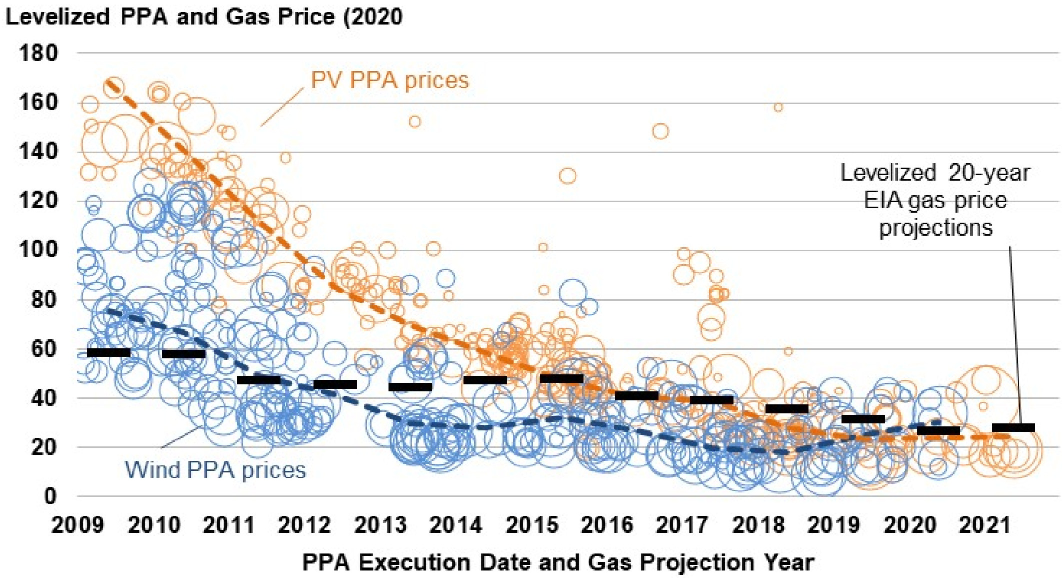
Sunrun and SunPower Cost and Value, Q2 2021



- Residential installers reported higher costs in Q2 2021, y/y.
- While equipment costs have increased, Sunrun attributes the higher costs to an uptick in system builds that have not yet reached completion.
- These costs also include a certain percentage of systems installed with storage.
  - In Q2 2021, SunPower reported that 23% of its residential sales also had a battery.
  - Sunnova, another leading residential installer, reported an attachment rate of 28%, and Sunrun reported that in some areas (such as San Francisco) close to 100% of customers choose to add batteries.

Sources: Corporate filings.

U.S. Utility-Scale PV PPA Pricing



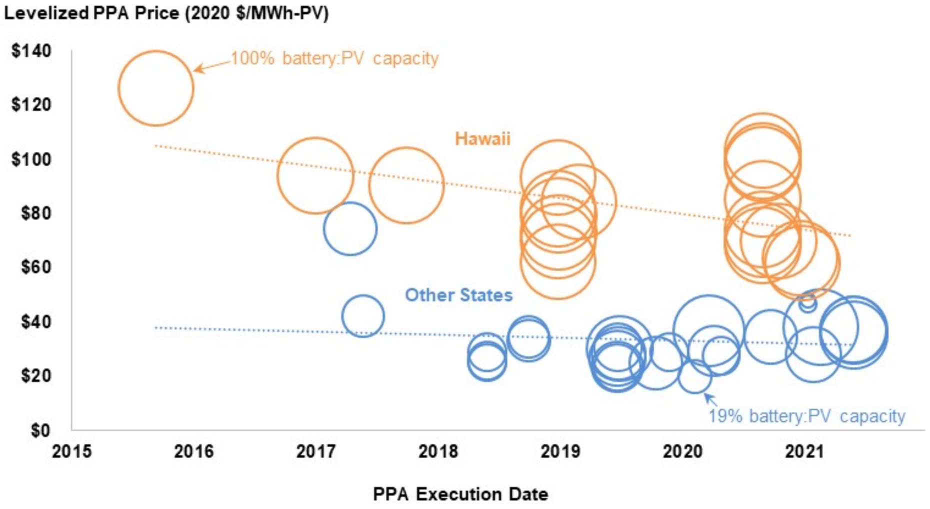
- In 2021, PPAs for U.S. utility-scale PV systems are priced at $20/MWh for projects in CAISO and the non-ISO West, and $30-$40/MWh for projects elsewhere in the continental United States.
- Nationwide, average PPA prices have fallen by ~85% (or 15% per year) since 2009.
- Solar PPA prices are now often competitive with wind PPA prices, as well as the cost of burning fuel in existing gas-fired generators.

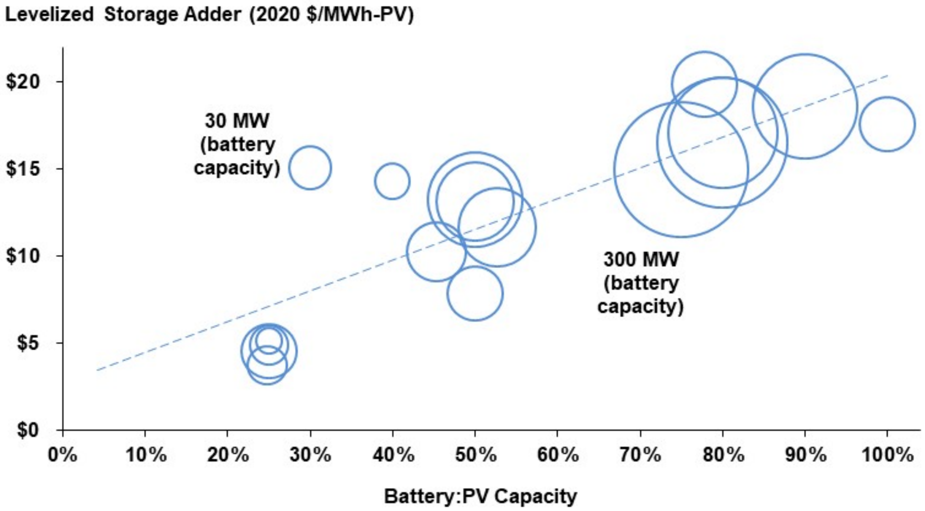
Source: Bolinger, M., J. Seel, C. Warner and D. Robson. 2021. *Solar Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States: 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory

U.S. Utility-Scale PV+Battery PPA Pricing

- LBNL also collected pricing data from a sample of PV+battery hybrid systems, which includes 47 PPAs, totaling 5.4 GWAC of PV and 3.1 GWAC of batteries.
- Since 2015, the overall trendline in PPA price trends downward.

- As to be expected, the premium on storage (relative to a PV-stand-alone PPA price) is highly dependent on the amount of storage added (relative to the size of the PV system).
  - The "levelized storage adder" increases linearly with the battery:PV capacity ratio: ~$5/MWh-PV at 25% battery:PV capacity, ~$10/MWh at 50%, ~$20/MWh at 100%.

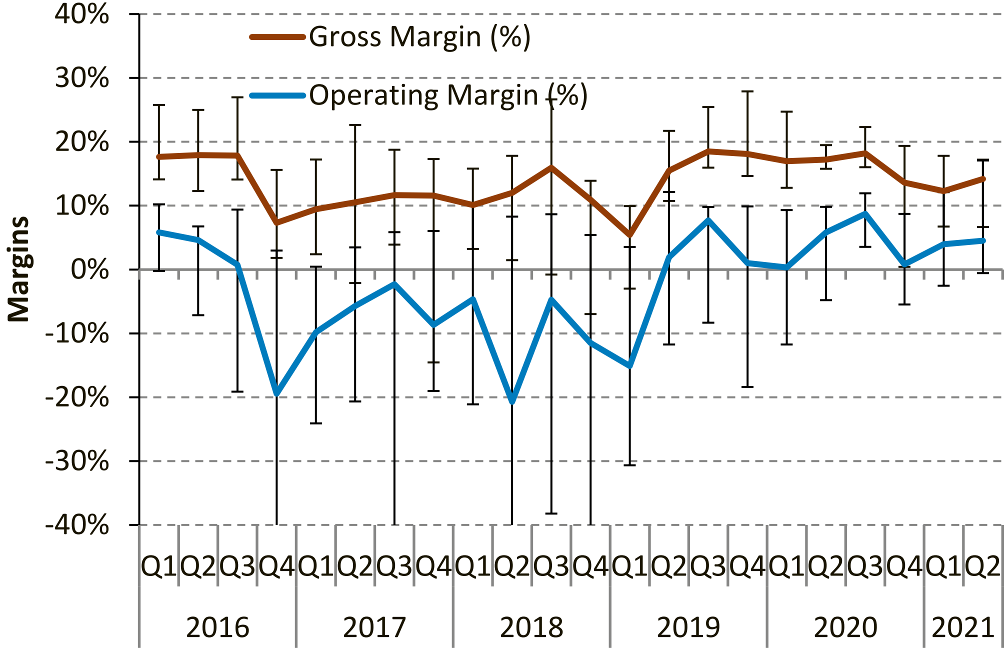




Source: Bolinger, M., J. Seel, C. Warner and D. Robson. 2021. *Solar Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States: 2021 Edition*. Berkeley, CA: Lawrence Berkeley National Laboratory

- **In In H1 2021, U.S. c-Si module production dipped 7% y/y, while thin-film (i.e., CdTe) production peaked, increasing 57%, y/y.**
  - In H1 2021 c-Si and thin film manufacturing had a utilization rate of 49% and 95%, respectively.
- **13.8 GW of PV modules were imported into the United States in H1 2021, down 3% y/y.**
- **1.4 GW_{DC} of cells were also imported in H1 2021, up 11%.**

PV Manufacturers' Margins

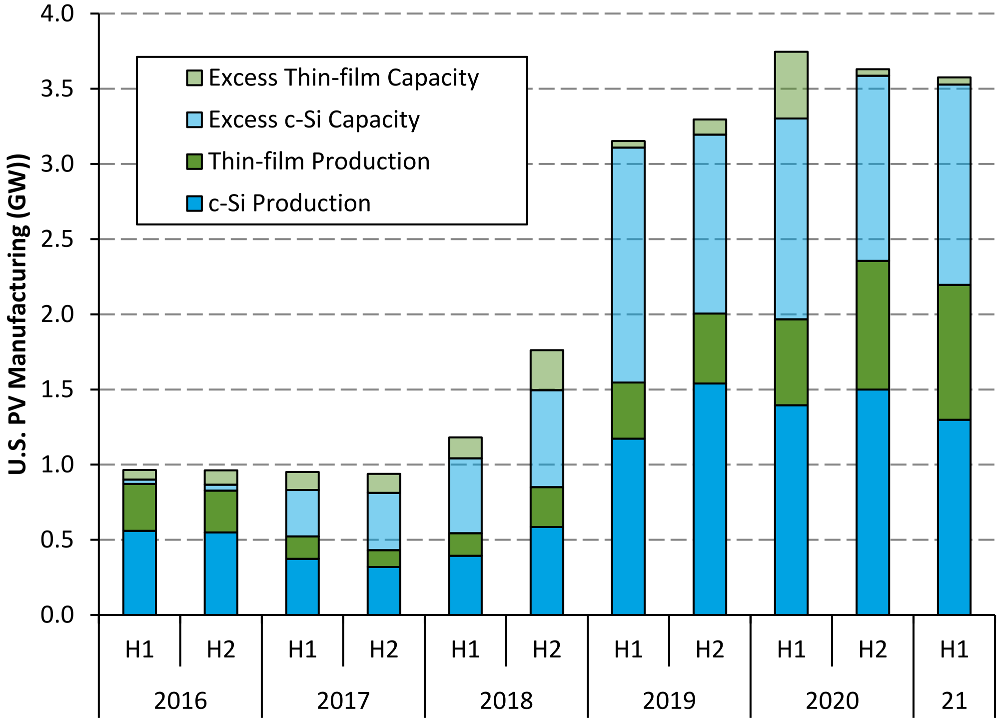


Lines represent the median, with error bars representing 80th and 20th percentiles for the following companies in Q2 2021: Canadian Solar, First Solar, JA Solar, Jinko Solar, LONGi, Maxeon, Motech Industries, Renesola, Risen, Shanghai Aerospace, Tongwei, Trina Solar, and United Renewable Energy. Margin data from Hanwha Q Cells, Sunpower, and Yingli are also included from Q1 2010 to Q1 2021 where available.

Source: Company figures based on public filings and finance.yahoo.com.

- PV manufacturers, mostly comprising Chinese companies, have generally been profitable since 2019.
- The median gross margin of the publicly traded PV companies represented to the left increased in Q2 2021, remaining above historical averages.
- There continues to be significant variation by individual companies as individual factors come into play.

U.S. Module Manufacturing



- In H1 2021, U.S. c-Si module production dipped 7% y/y, while thin-film (i.e., CdTe) production peaked, increasing 57%, y/y.
  - In H1 2021 c-Si and thin film manufacturing had a utilization rate of 49% and 95%, respectively.
- While U.S. PV cell production has ceased and no new plants have been announced, there have been a few c-Si module assembly plans announced. These include: Heliene's 100-MW facility in Florida (which was previously operated by SolarTech Universal) and 400 MW of additional capacity in Silfab's Washington plant.
- First Solar seems likely to surpass all U.S. c-Si module assembly capacity with the start of construction of a 3.3 GW factory in Ohio.

Source: Wood Mackenzie Power and Renewables/SEIA: U.S. Solar Market Insight Q3 2021 and previous U.S. Solar Market Insight reports.

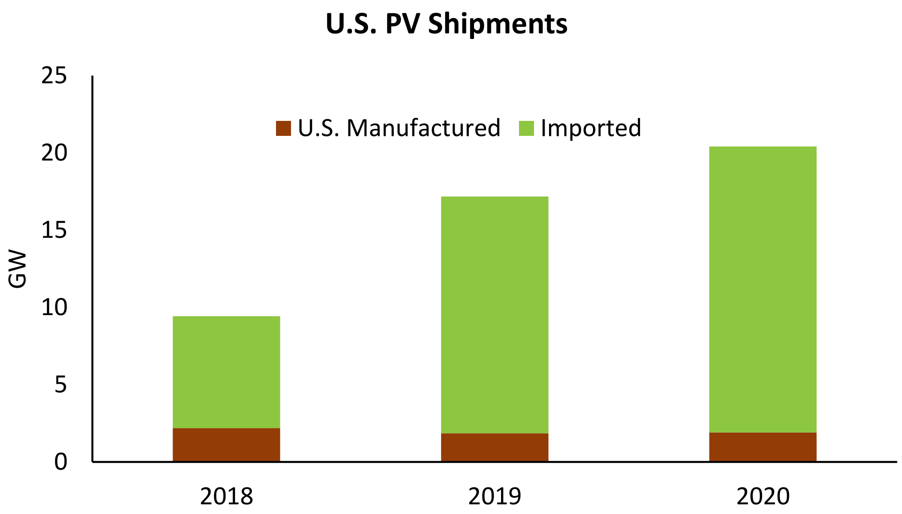
2021 US PV Manufacturing Announcements

Company	Capacity	Product	Target COD
Convalt Energy[1]	0.7 GW	c-Si modules	2022
First Solar[2]	3.3 GW	CdTe modules	H1 2023
Heliene	0.4 GW	c-Si modules	Q2 2022
NanoPV	TBD	c-Si modules	TBD
Ubiquity Solar	0.35 GW	c-Si cells	Q4 2022
Leading Edge	0.02 – 1 GW	c-Si wafers	2023-2024
Maxeon[3]	3 GW	c-Si cells & modules	2023 or later
Reliance	1 GW	c-Si modules	TBD
Meyer Berger	0.4 – 2 GW	c-Si modules	Q4 2022
Philadelphia Solar	1 GW	c-Si modules	Q3 2022
Violet Power[1]	3 – 5 GW	c-Si WCM	TBD

Also: Wacker signed 5-year supply deal with JinkoSolar for 70,000 MT of polysilicon from both U.S. and German facilities[4]

- In June 2021, Senator Ossoff introduced the Solar Energy Manufacturing for America Act, which would incentivize the production of domestically manufactured polysilicon, wafers, cells, and modules.
- Based on 2021 announcements (and depending on incentives provided), U.S. PV manufacturing could grow to:
  - Modules (c-Si and thin-film): 12-15 GW of additional, bringing the total to 19-22 GW.
  - c-Si cells: 6-8 GW additional (and total).
  - Thin-film: 3.3 GW, bringing total to 6 GW.
  - Wafer/ingot: 4-6 GW additional (and total)
  - Polysilicon: no additional announcements, total 20 GW.

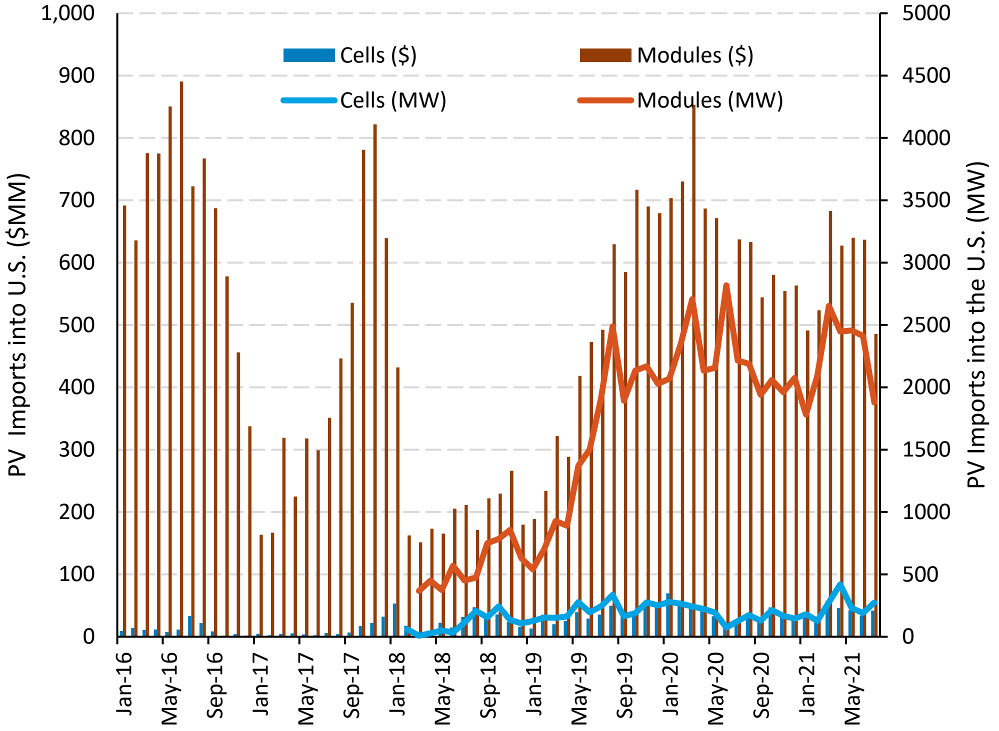
U.S. PV Dependence on China



- The vast majority of PV supplied to the U.S. market is imported.
- While China represents only a small fraction of those imports, those goods rely heavily on the Chinese supply chain upstream.

Sources: EIA, EIA-63B, *Photovoltaic Module Shipments Report*.

Module and Cell Import Data

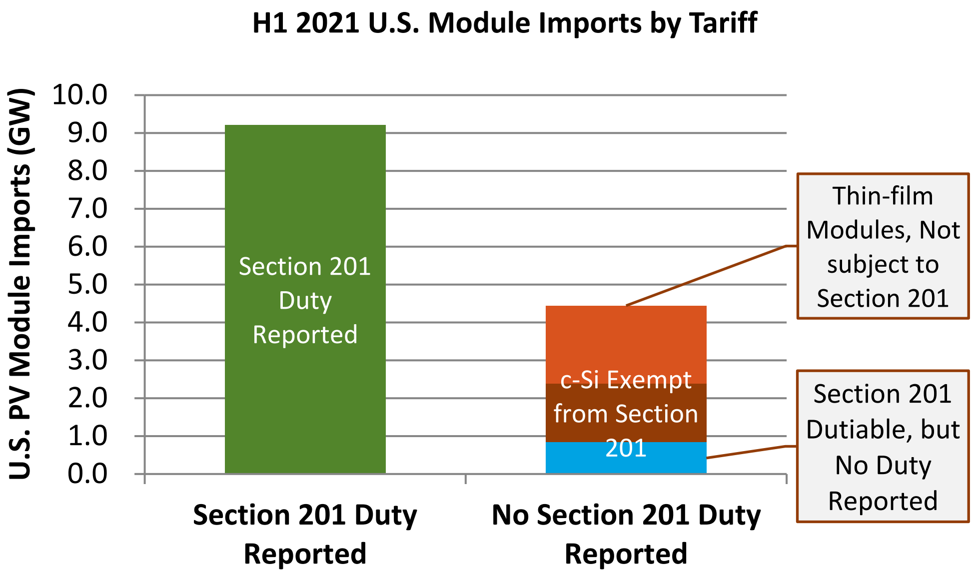


- 13.8 GW of PV modules were imported into the United States in H1 2021, down 3% y/y.
- 1.4 GW_{DC} of cells were also imported in H1 2021, up 11%.
- In addition to imports, First Solar produced approximately 1 GW_{DC} of CdTe PV modules.

Note: We adjusted Thailand's reported imports in megawatts for February because of a likely reporting error.

Sources: First Solar public filings; Imports, by Value and MW: U.S. International Trade Commission, 2021.

Q1 2021 U.S. Module Imports by Tariff

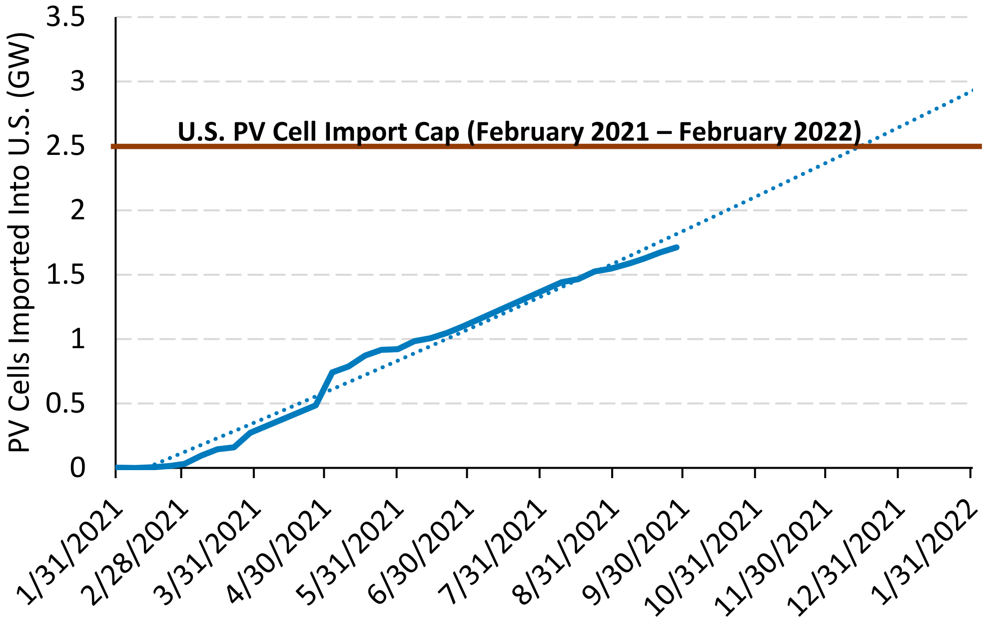


- In H1 2021, 4.4 GW_{DC} of imported PV modules (33% of all PV module imports) did not report a tariff.
- For approximately 0.8 GW of imported c-Si modules—subject to Section 201—no duties were reported. Why this happened is unclear.

Note: Module data uses codes 8541406015, 8541406020, and 8541406035. We assumed all modules not subject to Section 201 tariffs are reported under “Free under HS Chapters 1-98” or “Entered into U.S. Virgin Islands,” with exemptions coming from HTS code 8541406015, and technologies not applicable reported under HTS code 854140603. We assume all panels subject to Section 201 duties have been reported under “Dutiable- HS chapter 99.” We adjusted Thailand’s reported imports in megawatts for February because of a likely reporting error.

Source: Imports, by MW: U.S. International Trade Commission, 2021.

Cell Import Data by Tariff



- A 2.5-GW_{DC} quota exempts the first 2.5 GW of imported c-Si PV cells each reporting year subject to the Section 201 tariff.
  - In the first 3 years of the tariffs, the United States did not reach the cap.
- Based on PV cell imports since February 2021, the United States is projected to exceed the cap in December; however, manufacturers may pull back imports before then.

Note: Cell data uses HTS codes 8541406025.

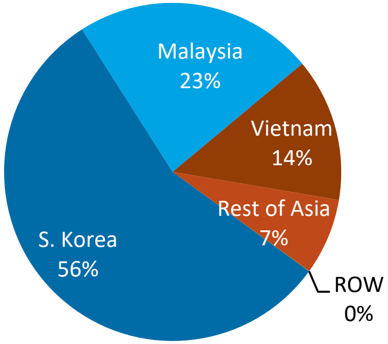
Sources: Imports, by MW: U.S. International Trade Commission, 2021; U.S. Customs and Protection Commodity Status Reports.

Module and Cell Imports by Region

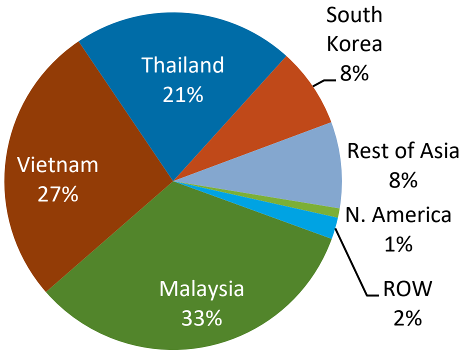
- In H1 2021, most PV cells imported into the U.S. came from South Korea, likely to support the LG and Hanwha Q Cells module assembly plants in Alabama and Georgia. The remainder of imported cells mostly came from Malaysia and Vietnam.

- The U.S. imported most of the 11.6 GW of PV c-Si modules from Southeast Asia in H1 2021, as well as South Korea.
  – The U.S. also imported approximately 0.6 GW of thin-film modules from Vietnam and Malaysia, where First Solar—the manufacturer of CdTe modules—has manufacturing facilities.

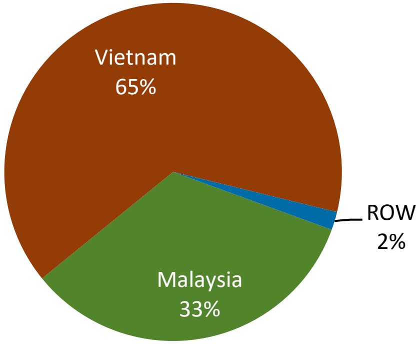
H1 2021 U.S. Cell Imports by Region (1.4 GW)



H1 2021 U.S. c-Si Module Imports by Region (11.6 GW)

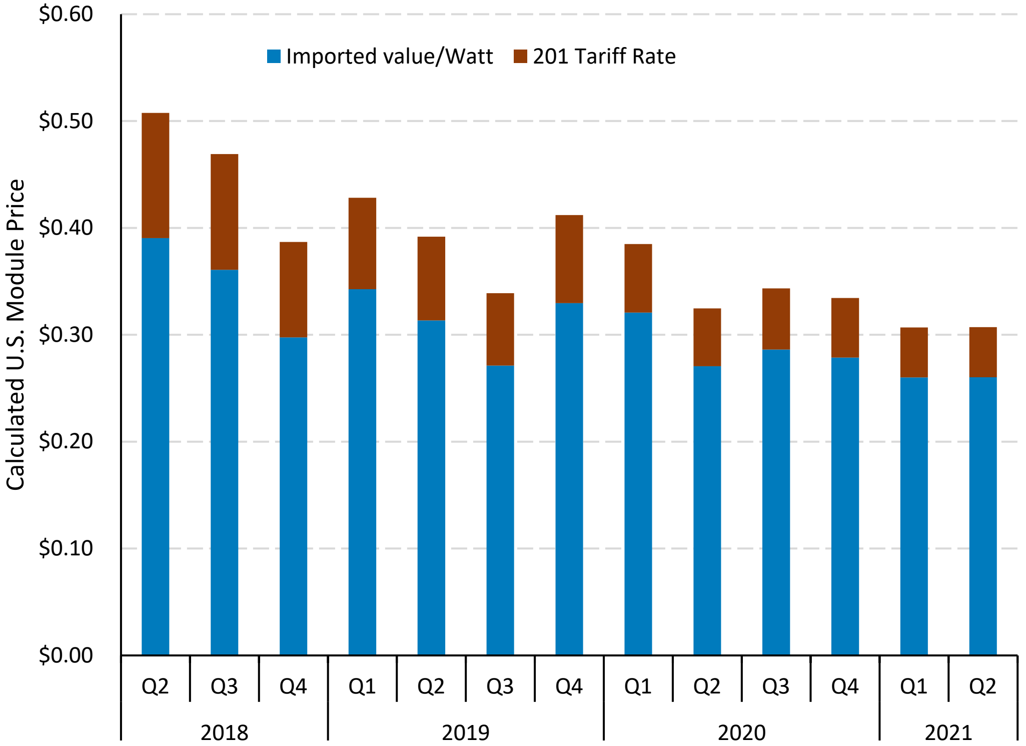


H1 2021 U.S. Thin-film Module Imports by Region (0.6 GW)



Note: Cell data uses HTS codes: 8541406030, 8541406025; c-Si module data uses codes: 8541406015, 8541406020; thin-film data uses code: 8541406035. We adjusted Thailand's reported imports in megawatts for February because of a likely reporting error. We also adjusted India data reported as code 8541406035 to c-Si.
Sources: Imports, by value and MW: U.S. International Trade Commission, 2021.

Calculated U.S. Module Pricing

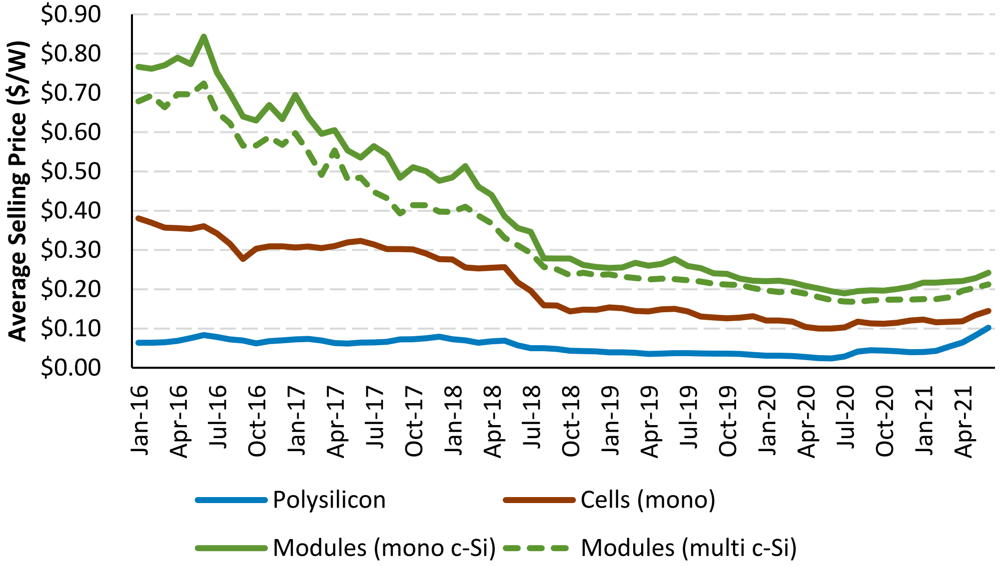


- Based on the reported value and capacity of imported PV modules, the average price of a PV module in the United States before tariffs dropped from $0.39/W in Q2 2018 to $0.26/W in Q2 2021.
- Additionally, as a result of the underlying price reduction and step down of the Section 201 tariff, these duties have been cut by 60%, on a per-watt basis (from approximately $0.12/W to $0.05/W).

Source: Imports, by Value and MW: U.S. International Trade Commission, 2020.

- **At the end of September, the spot price of polysilicon was $31/kg—its highest mark in 10 years.**
  - The increased price of polysilicon is driving up wafer/cell/module pricing, however not nearly to the same degree, with prices still below what they were 2 years ago.
- **In Q2 2021, U.S. mono c-Si module prices rose $0.01/W, q/q, and were flat y/y— trading at a 59% premium over global ASP.**

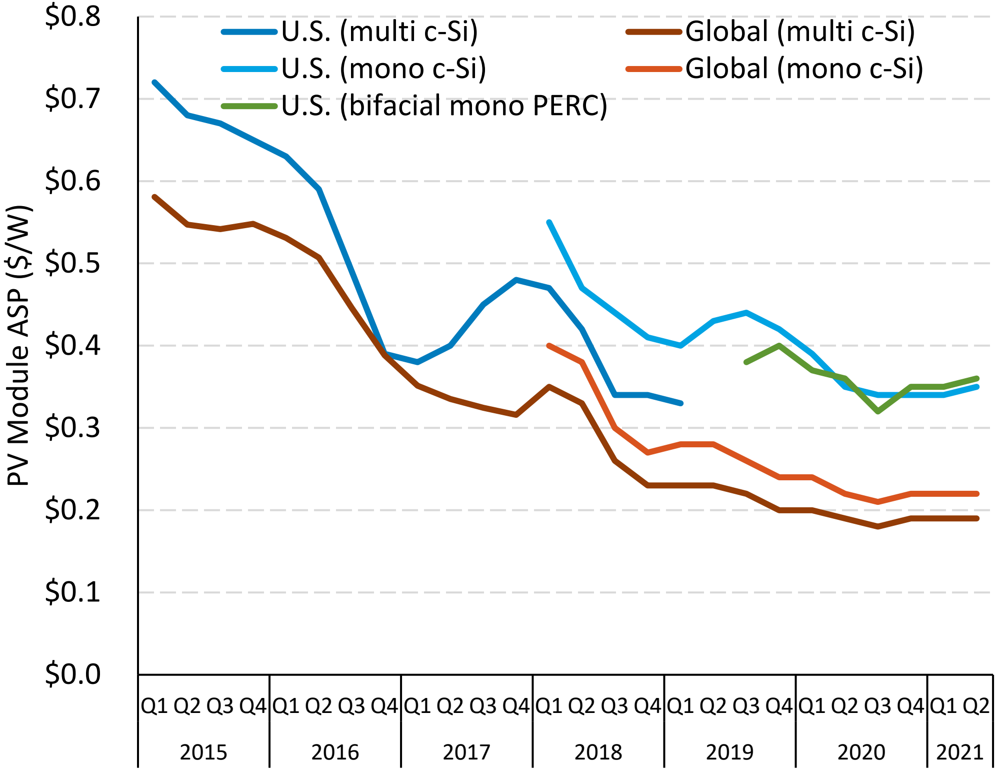
PV Value Chain Spot Pricing



- At the end of September, the spot price of polysilicon was $31/kg—its highest mark in 10 years.
  - The price impact has been muted, historically, due to lower polysilicon usage per watt over time.
- The increased price of polysilicon is driving up wafer/cell/module pricing, however, not nearly to the same degree, with prices still below what they were 2 years ago.
  - Mono- and multi-c-Si PV module global price averages were approximately $0.24/W and $0.21/W, respectively, in September 2021.

Source: BloombergNEF Solar Spot Price Index (10/04/21).
Kilogram to Watt Conversion: 4.78 grams per watt (2016); 4.73 grams per watt (2017), from Cowen & Co. (05/11/17) add Deutsche Bank (07/19/17); 4.35 (2019); 4.10 (2019); 3.85 (2020); 3.60 (2021) from Bernreuter.

Module Average Selling Price: Global Versus United States



- In Q2 2021, U.S. mono c-Si module prices rose $0.01/W, q/q, and were flat y/y—trading at a 59% premium over global ASP.
  - Before Q4 2020, bifacial modules were trading a few cents below mono c-Si in the United States because of an exemption to the Section 201 tariffs; however, that exemption was removed in Q4 2020.

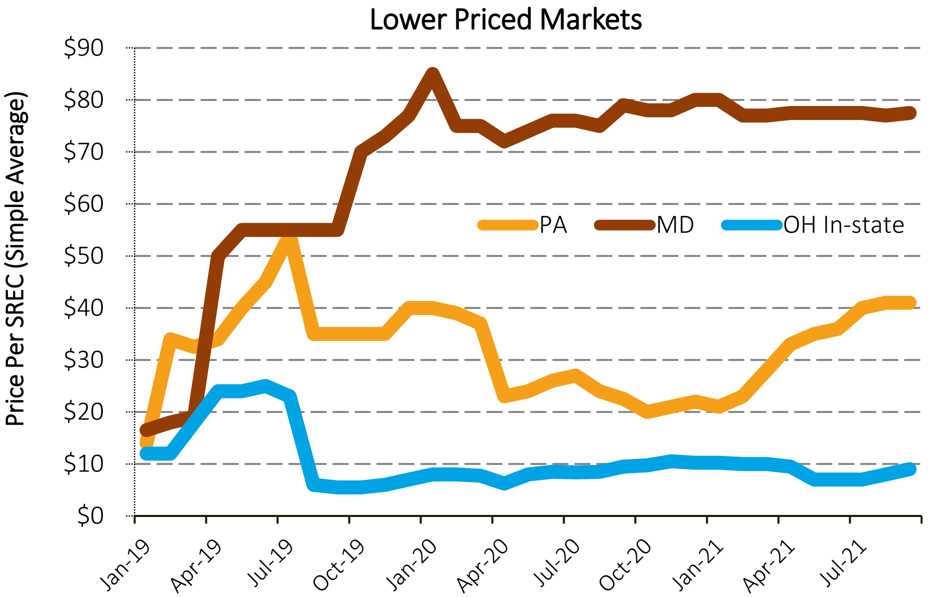
Source: Wood Mackenzie Power & Renewables/SEIA.

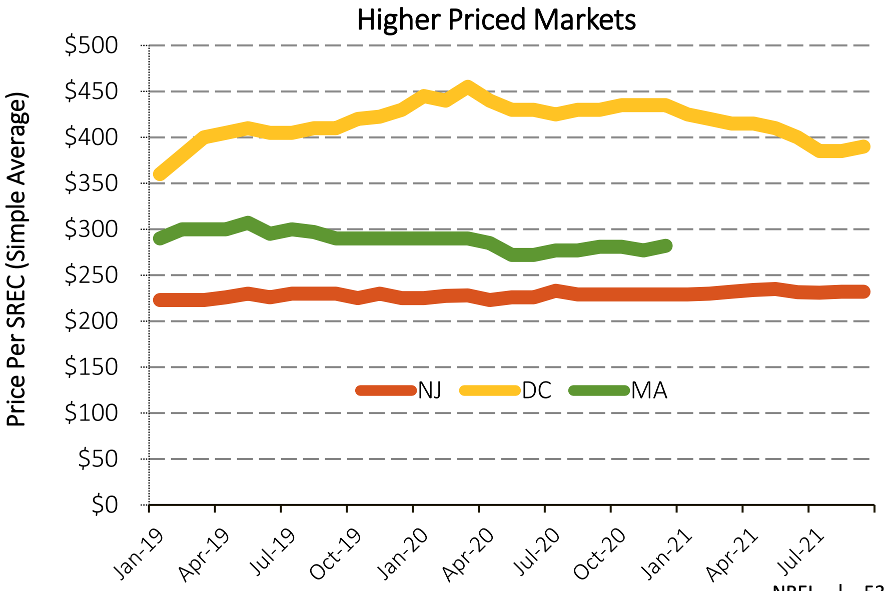
- **Solar stocks gained heavily, following the last U.S. presidential election, due to interest in ESG funds; however, bets against the market have surged due to a variety of solar industry challenges.**
  - Logistical headaches, including elevated freight costs
  - Policy uncertainty and supply-chain disruption caused by United States and China disputes
  - Costs have risen in 2021, proving particularly challenging for companies that have seen a drop in demand.

SREC Pricing

- Pennsylvania SRECs have increased 86% in 2021, with the introduction of legislation to significantly increase its RPS solar carve-out.
  – All other SREC markets were relatively flat or went down.

- On June 1, Maryland's updated RPS was passed into law. It gives the state more time to get to its 14.5% solar carve-out by 2030 (starting in 2022) and increases the compliance payment penalties (starting in 2023).
- In late June, New Jersey approved its SREC successor program, which will support the development of 3.8 GW of PV by 2026, doubling the state's current solar capacity to about 10% of electricity supply.

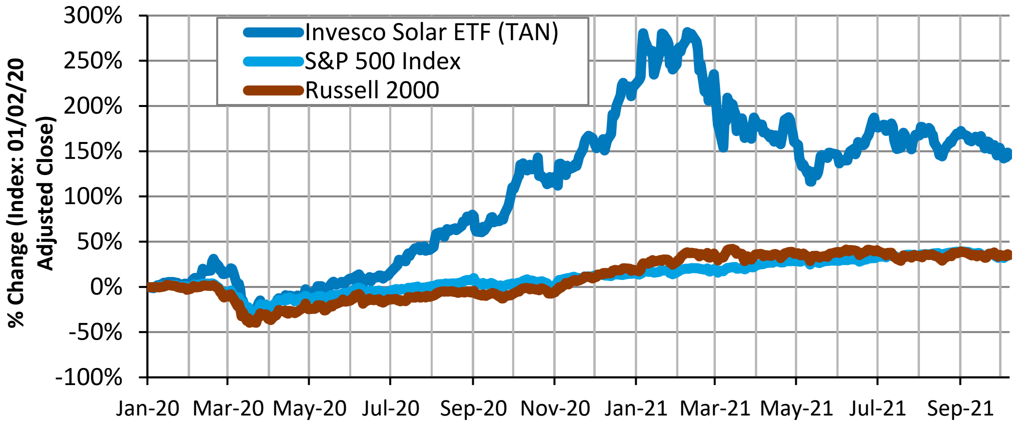




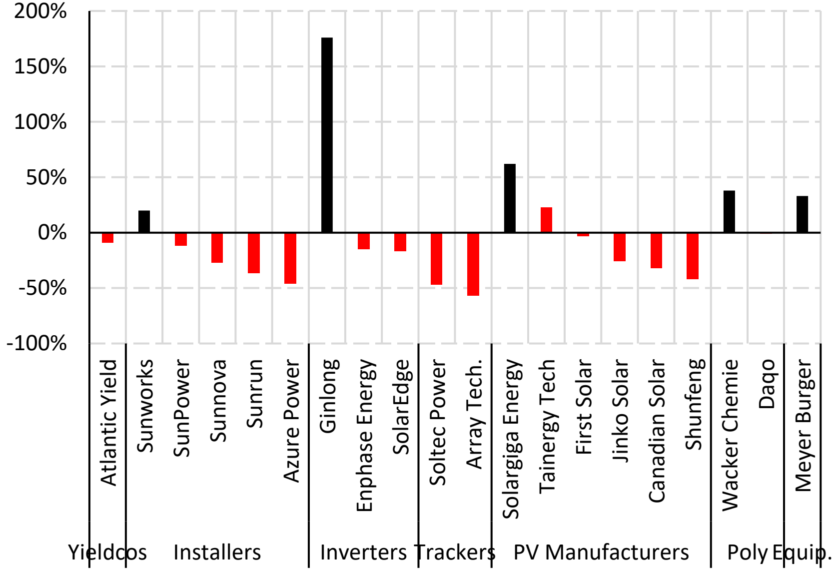
Source: SRECTrade, https://www.srectrade.com/, accessed 10/04/21. SRECTrade (06/04/21, 06/30/21)

Stock Market Activity

- Solar stocks gained heavily, following the last U.S. presidential election, due to interest in ESG funds; however, bets against the market have surged due to a variety of solar industry challenges.
  - Logistical headaches, including elevated freight costs
  - Policy uncertainty and supply-chain disruption caused by United States and China disputes
  - Costs have risen in 2021, proving particularly challenging for companies that have seen a drop in demand.
  - The ETF is down 18% this year after surging 234% in 2020.



Individual Stock Performance (Q1-Q3 2021)



Note: The TAN index is weighted toward particular countries and sectors. As of 08/31/20, 52% of its funds were in U.S. companies. Its top 10 holdings, representing 63% of its value, were Sunrun, SolarEdge, Enphase, First Solar, Xinyi, Vivint Solar, Daqo, SunPower, Solaria Energia, and Encavis.

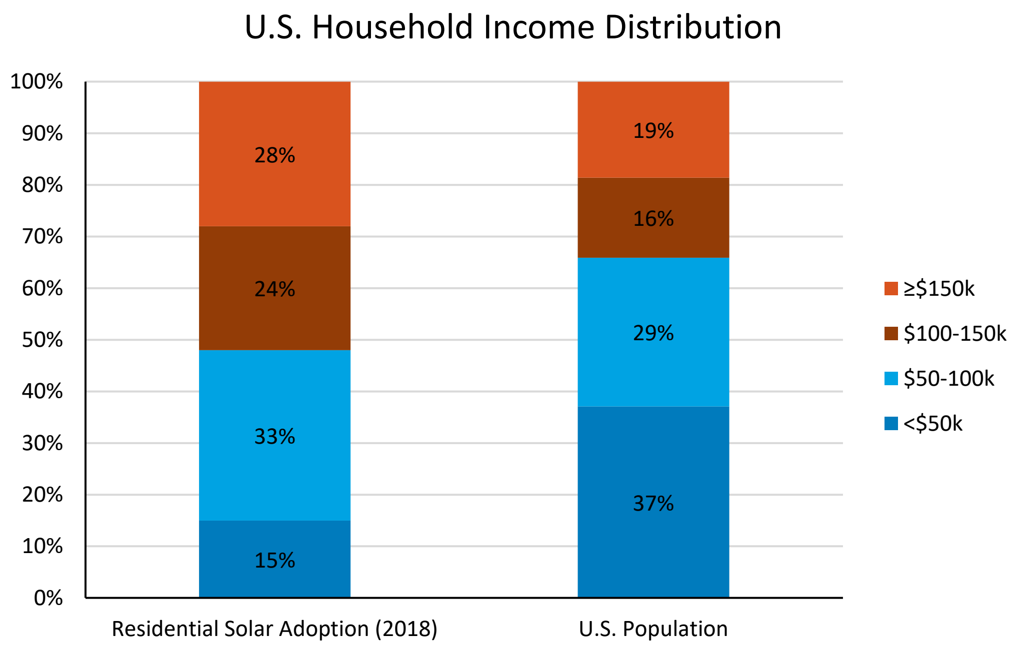
Sources: Bloomberg (08/31/21). Stock market: Yahoo Finance (10/08/21).

ITC Challenges for LMI Customers

- **LMI households do not represent an equitable portion of those benefitting from solar, and the ability for households to utilize the federal tax credit may explain some of that gap.**

- **Based on data from the Congressional Budget Office, 60% of U.S. households, on average, do not pay enough in taxes to use the solar investment tax credit.**

Equity and the Environment



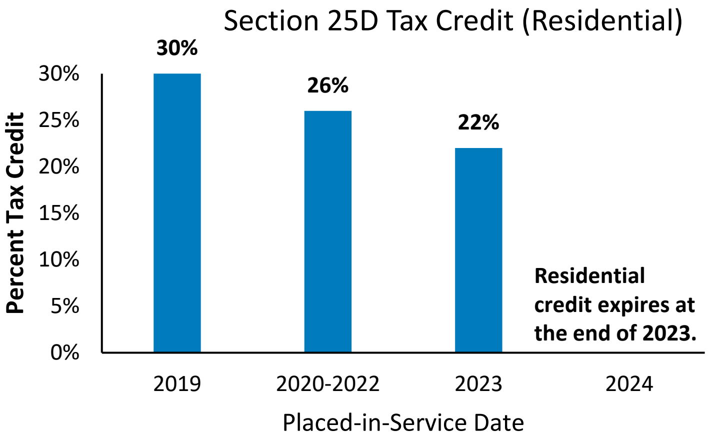
- LMI households do not represent an equitable portion of those benefitting from solar.
    - Despite households earning less than $100k representing two-thirds of all U.S. households, they adopted less than half of all residential solar systems in 2018.
    - The contrast is even more stark for those households earning less than $50k per year.

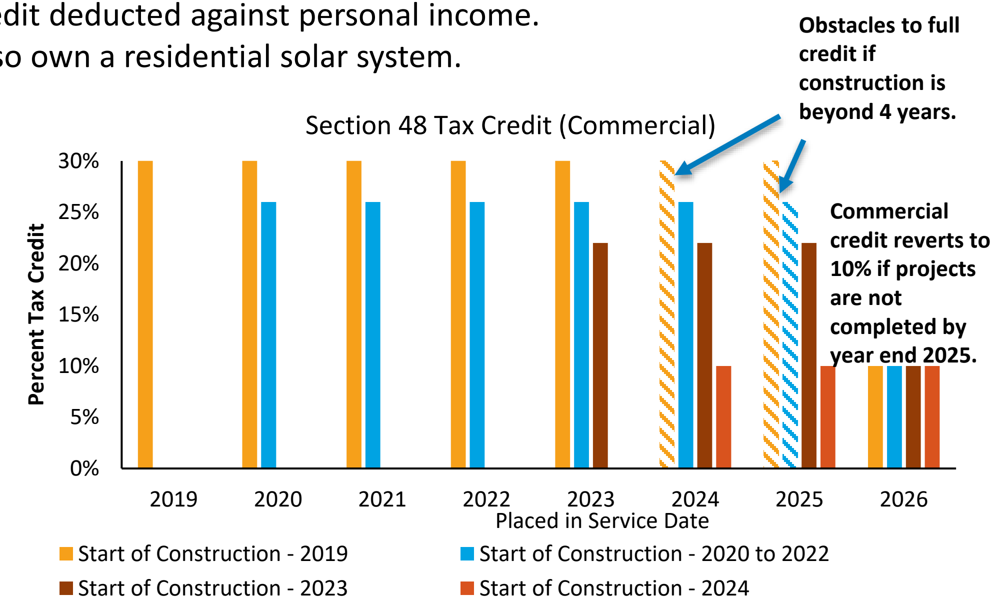
Sources: U.S. Census Bureau; LBNL, Income Trends among U.S. Residential Rooftop Solar Adopters

Investment Tax Credits

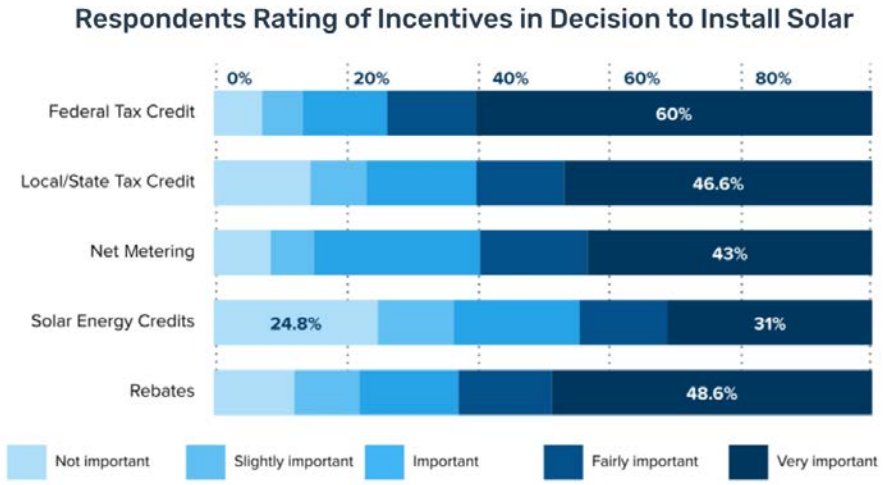
Residential (25D) and Commercial (48)

- Part of the reason for the difference in solar adoptions rates by income level is the primary federal incentive for solar PV systems, the investment tax credit—providing a certain percentage of system costs back to system owners in the form of a tax credit.
- There are two investment tax credits, each with its own set of rules:
  - Section 25D is for households, with the tax credit deducted against personal income.
  - Section 48 is for businesses. A business can also own a residential solar system.





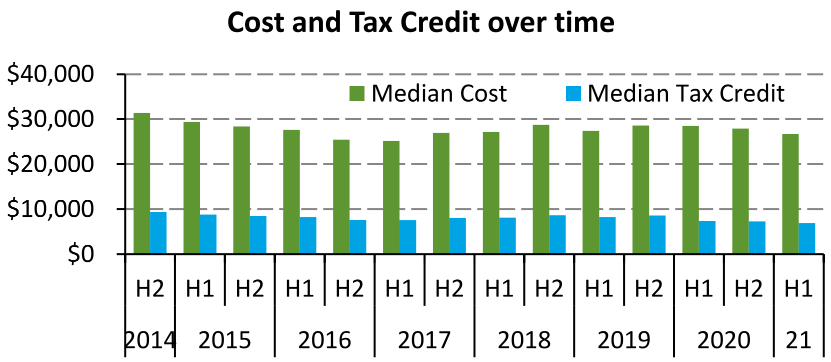
Importance of Federal Tax Credit

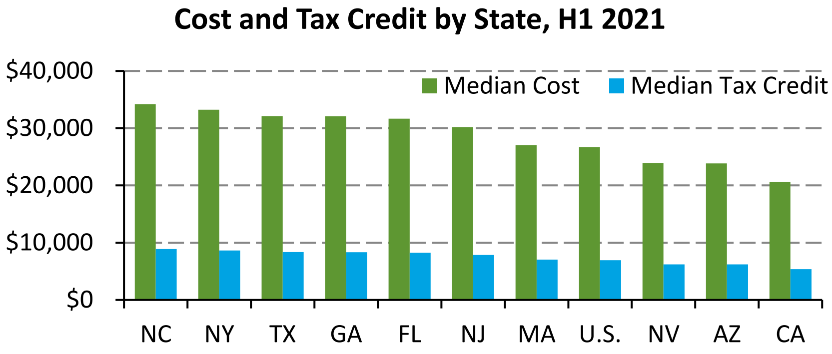


- A recent survey found that the federal tax credit was the most important incentive for homeowners installing a solar PV system.

Source: Beacn "Residential Solar Consumer Insights." April 2021.

Residential PV System Costs and Tax Credit Amount

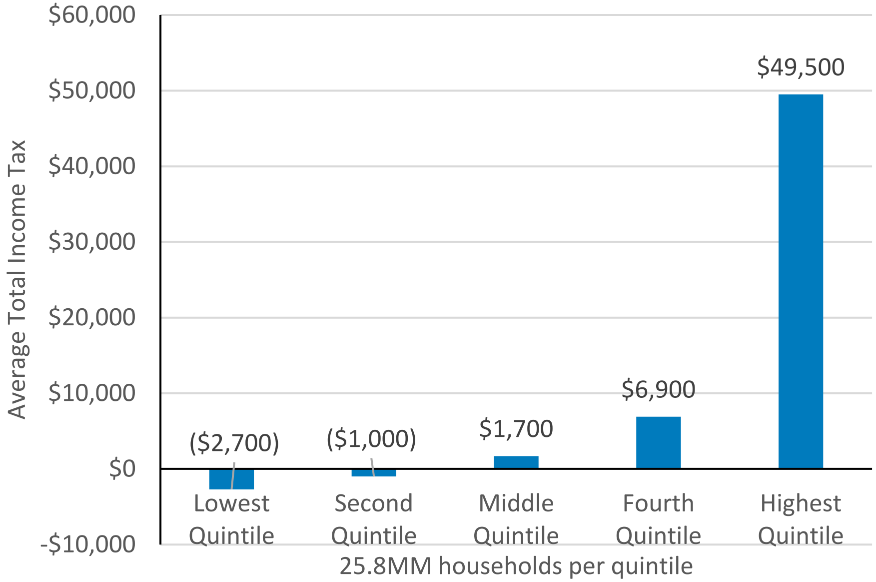




- The price of a PV system has generally gone down over time, however on average it still costs more than $25,000, providing a tax credit of a little under $7,000.
- System price varies by multiple factors, including system size, location, and installer.
  - The median price of California system was $21,000, providing a tax credit of $5,400, while the median price of a North Carolina system was $34,000, providing a tax credit of $8,900.
    - Systems in North Carolina are generally larger than those in California, in part due to the need for more electricity (e.g., air conditioning).

Note: price based on winning quoted price.
Source: EnergySage, “Solar Market place Intel Report H2 2020 – H1 2021.”

Personal Income Tax by Quintile of the Population

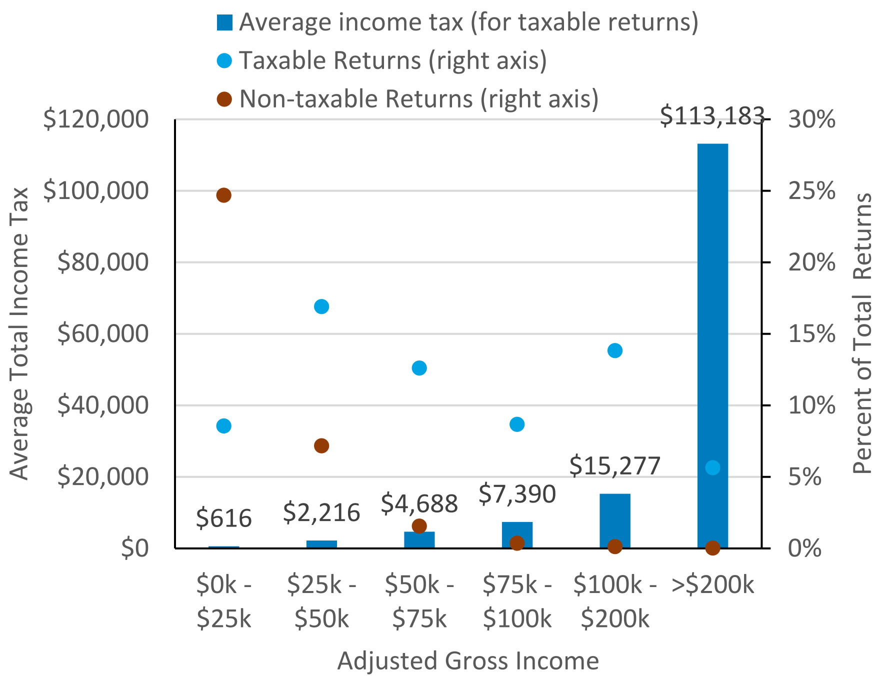


Given a tax credit range of $5,000 to $10,000:

- Based on data from the Congressional Budget Office, 60% of U.S. households, on average, do not pay enough in taxes to use the solar investment tax credit.
  - The tax credit can be used over multiple years but becomes less valuable due to: (1) the time value of money, and (2) the ability to defer upfront costs.

Source: CBO Report, “The Distribution of Household Income, 2018.”

Average Income Tax for Taxable Returns, by Income Bracket



- Similar data from the IRS shows the same themes, with those paying taxes requiring at least a $75,000 income to utilize the average solar tax credit amount.
- We can also see that about 35% of the population does not submit a taxable return, with most of those (25%) coming from those making less than $25,000 a year.
- Research has also shown that taxpayers making less than $40,000 per year (60% of filers) almost never use the solar tax credit.

Sources: IRS, "All Returns: Selected Income and Tax Items, by Size and Accumulated Size of Adjusted Gross Income, Tax Year 2018 (Filing Year 2019)." Severin Borenstein and Lucas W. Davis. "The Distributional Effects of U.S. Clean Energy Tax Credits." NBER Working Paper 21437, July 2015. www.nber.org/papers/w21437.

Other Factors

Third-Party Ownership (TPO)

- Some of the issues with the ability to use tax credits can be solved through businesses, instead of households, owning the PV system (i.e., TPO).
  - An LBNL study found that 57% of LMI households with solar in 2016 used TPO, compared with 48% of non-LMI households.
- However, TPO have credit and income qualifications and therefore LMI customers may not be eligible to obtain a solar system from a TPO.

Loan Requirements

- Even if residential customers could take advantage of the federal tax credit (i.e., if it were refundable) they would still need to pay for the other 76% of the system, potentially costing tens of thousands of dollars.
- Solar loans are currently the most popular financing solution for residential customers, providing the full cost of a system, and often a short-term loan for the tax credit. However, they also typically have credit and income qualifications; LMI customers may either be ineligible, or the interest rates may be significantly higher.
  - That said, research has also shown that a significant portion of LMI customers do have sufficient credit. For example, 72% of Connecticut homeowners earning less than 60% of the state median income (SMI) have FICO scores over 650, as well as 80% of homeowners earning 60%–80% of (SMI).

Other Factors which may be correlated to income

- Home ownership, building stock (e.g., roof accessibility/suitability/age), frequency of moving, seasonality of income, system size/energy use, trust of product/provider.

Sources: LBNL, Income Trends among U.S. Residential Rooftop Solar Adopters; Clean Energy States Alliance, Bringing the Benefits of Solar Energy to Low-Income Consumers.

Thank You

www.nrel.gov

NREL/PR-7A40-81325

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Special thanks to Nate Blair, Adam Warren, and Mike Meshek.

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

List of Acronyms and Abbreviations

ASP	average selling price
BNEF	Bloomberg New Energy Finance
CAISO	California Independent System Operator
CAPEX	capital expenditures
C&I	commercial and industrial
c-Si	crystalline silicon
CdTe	cadmium telluride
CSP	concentrating solar power
DC	direct current
DPV	distributed PV
EIA	U.S. Energy Information Administration
ESG	environmental, social, and governance
ETF	exchange traded fund
G&A	general and administrative expenses
GW	gigawatt
GWh	gigawatt-hour
H1	first half of year
H2	second half of year
HECO	Hawaii Electric Company
IEA	International Energy Agency
IRS	internal revenue service
ITC	investment tax credit
K	thousand
kg	kilogram
kW	kilowatt
kWh	kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory
LCOE	levelized cost of energy
LMI	low and moderate income
m	Meter
MLPE	module-level power electronics
MMcf	million cubic feet
Mono c-Si	monocrystalline
Multi c-Si	multicrystalline
MW	megawatt
MWh	megawatt-hour
NEM	net energy metering
O&M	operations and maintenance
Poly	polysilicon
PPA	power purchase agreement
PV	photovoltaic
ROW	rest of world
Q	quarter
S&P	Standard and Poor’s
SEIA	Solar Energy Industries Association
SG&A	selling, general and administrative expenses
SMART	Solar Massachusetts Renewable Target
SMUD	Sacramento Municipal Utility District
SREC	solar renewable energy certificate
TAN	Invesco Solar ETF
TBD	to be determined
TOU	time-of-use
TWh	terawatt-hour
W	watt
y/y	year over year
YTD	year to date