TESTIMONY OF

CHRISTOPHER MANSOUR
VICE PRESIDENT, FEDERAL AFFAIRS
SOLAR ENERGY INDUSTRIES ASSOCIATION

BEFORE THE

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HEARING ON

Powering America: Defining Reliability in a Transforming Electricity Industry

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Solar Energy Industries Association
600 14th Street NW, Suite 400
Washington, DC 20005
(202) 682-0556
www.seia.org

Chairman Upton, Ranking Member Rush, and Members of the Subcommittee,

Thank you for the opportunity to provide testimony on solar and its contributions to grid reliability. I am Christopher Mansour and I serve as the Vice President of Federal Affairs for the Solar Energy Industries Association (SEIA). I am testifying on behalf of SEIA's 1,000 member companies and the 260,000 American citizens employed by the solar industry. SEIA represents the entire solar industry, encompassing all major solar technologies (photovoltaics, concentrating solar power and solar water heating[1]) and all points in the value chain, including financiers, project developers, component manufacturers and solar installers. Before I begin my testimony, let me thank Chairman Upton and Ranking Member Rush for their leadership and support of solar energy. We are grateful that the Committee recognizes the increasingly important contributions solar makes to our energy supply and the economy, for the benefit of the nation.

I. Introduction

The Solar Energy Industries Association is celebrating its 43rd year as the national trade association of the U.S. solar energy industry, having been established in 1974. Through advocacy and education, SEIA and its 1,000 member companies are building a strong solar industry to power America. As the voice of the industry, SEIA works to make solar a mainstream, significant energy source by expanding markets, removing market barriers, strengthening the industry and educating the public on the benefits of solar energy.

Our nation is graced with some of the world's best solar resources, in both the quality and quantity of the sunlight we receive as well as the proximity of our best solar areas to some of the country's largest cities and industries. Our exceptionally rich solar resources have much to offer the nation, its economy, and its environment. Solar can contribute substantially to a clean, sustainable domestic energy supply to power growth and prosperity for many decades to come. Stable, long-term policies, including tax, trade, and energy policies are the keystones to realizing solar's ability to deliver reliable, low-cost power to the nation. We are pleased to have this opportunity to address them and other factors needed to maintain the U.S. as a worldwide solar leader.

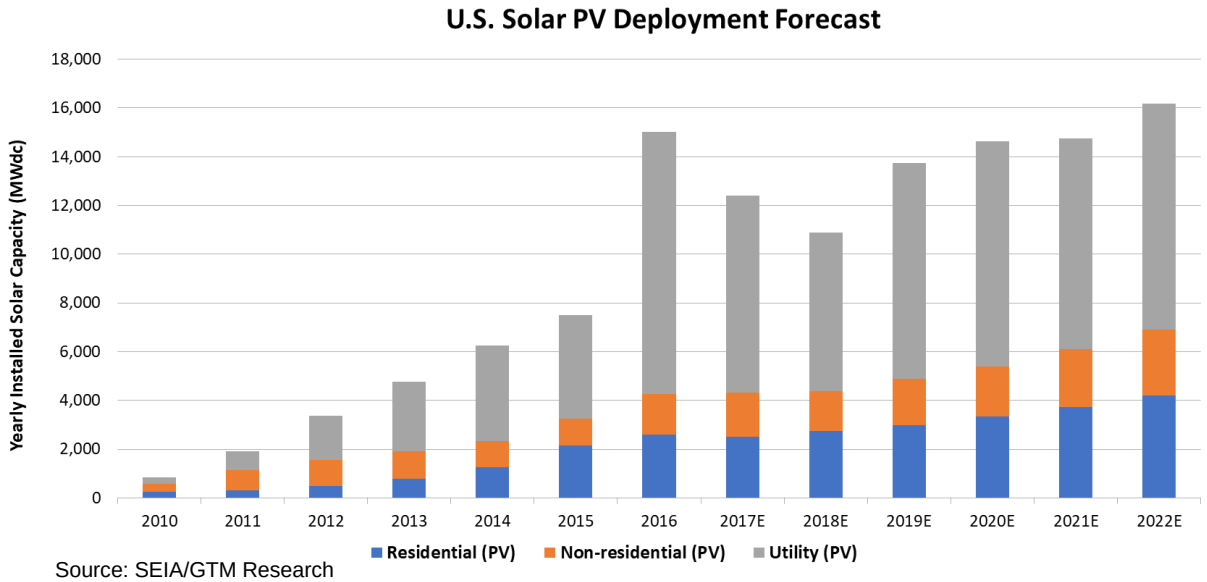
II. The U.S. Solar Industry: Recent Highlights and Future Prospects

Photovoltaic technology was invented in the U.S.A., developed as a marketable energy source

[1] For more information on each of these solar technologies, please see SEIA, "Solar Technologies," *available at* https://www.seia.org/initiative-topics/trade-tech-environment.

in the U.S.A., and last year, solar was the largest single source of electric generating capacity added in the U.S.A.

In recent years, America's solar industry has come a long way in converting its solar resources to the electrical energy our economy needs to thrive. Solar energy is a young industry, but it is growing fast. Solar capacity in the U.S. now exceeds 47 GW, enough to power 9.1 million homes.[2] The following graph illustrates solar's remarkable growth since 2010, including expected installations for the next five years:



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

This phenomenal growth is the result of private investment, technological innovation, a maturing industry and smart federal and state policies. The federal government has received a strong return on its investment of public dollars, with benefits to our economy that far exceed their costs.

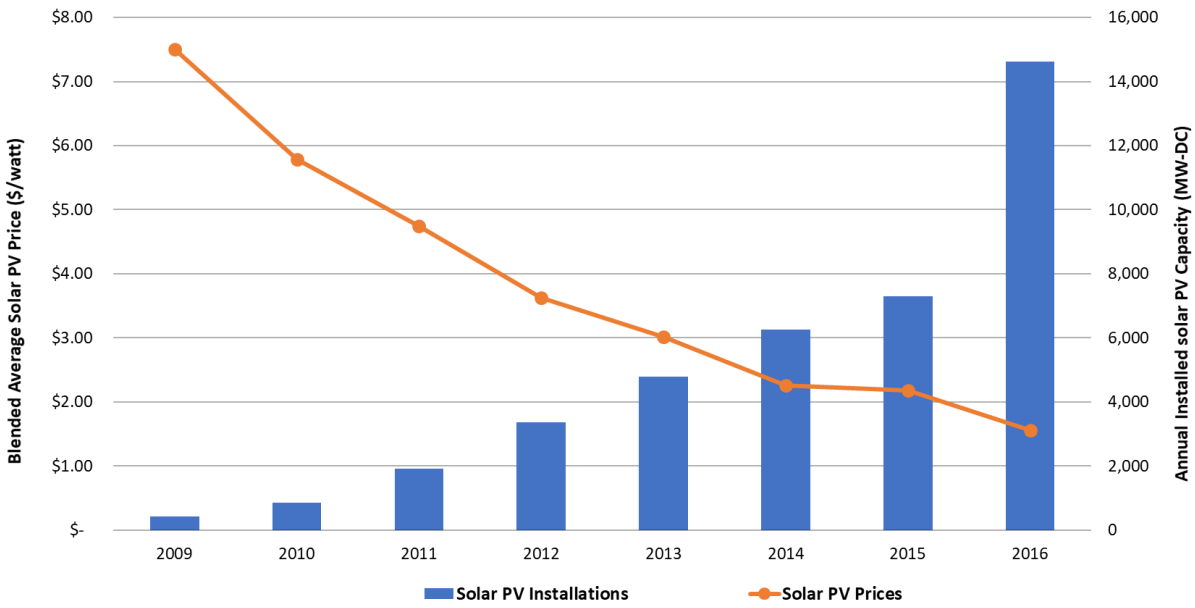
Despite solar's spectacular growth over the last decade, it still makes up only 1.4% of the nation's total electricity mix. By 2020 solar is expected to represent close to 4% of total electricity generated.

Although solar is growing quickly, the nation has just begun to tap into its solar resources. Solar's potential to serve the nation is far greater than its remarkable success to date. Solar power transforms the endless, free energy we receive from the sun into electric power to drive

[2] SEIA and GTM Research, "U.S. Solar Market Insight" report, *available at* https://www.seia.org/us-solar-market-insight.

commerce, industry and our way of life, at decreasing costs. Our nation can – and should – depend on its exceptional solar resources to power its exceptional future.

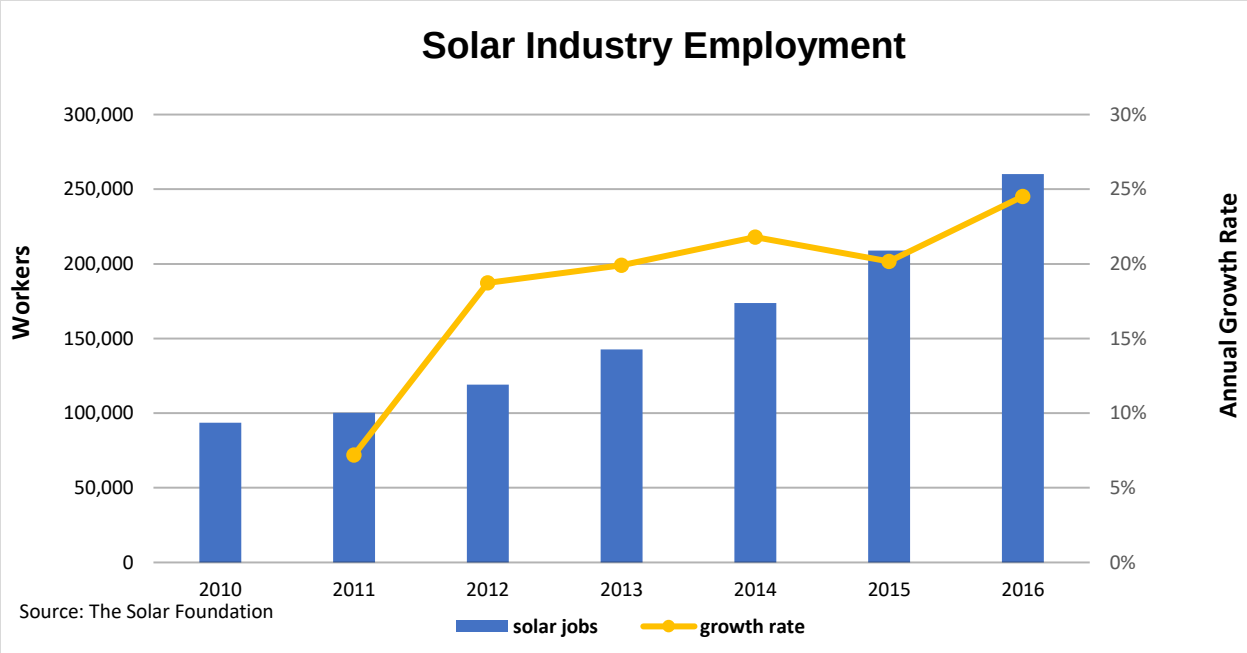
As solar provides increasing amounts of energy to the country, its costs are decreasing dramatically. As shown in the chart below, PV system prices are decreasing in every market segment, year-over-year.[3] Solar deployment is paying great dividends to the American economy and continues to act as catalyst to drive down future costs.



In addition, the 9,000 American solar companies employ more than 260,000 American workers and invest tens of billions of dollars every year into the American economy. In 2016, solar industry employment grew 25% over 2015 to reach over 260,000 workers, according to the Solar Foundation.[4]

[3] Data provided by SEIA and GTM Research.

[4] The Solar Foundation, "National Solar Jobs Census 2016," *available at* https://www.thesolarfoundation.org/national/.



Last year, the solar industry was responsible for one out of every fifty new jobs created in the U.S. These are jobs in fields ranging from contracting and engineering to manufacturing, R&D, and finance, with median wages topping $25/hour. While California leads the way in solar jobs, states like Nevada, Florida, Arizona, Texas and North Carolina each employ more than 7,000 solar workers.[5] In 2016, the Department of Energy reported that the U.S. solar industry employed more workers than the natural gas industry and more than twice as many workers as the coal industry. In fact, solar represented 18% of all U.S. energy jobs, second only to the oil industry.[6]

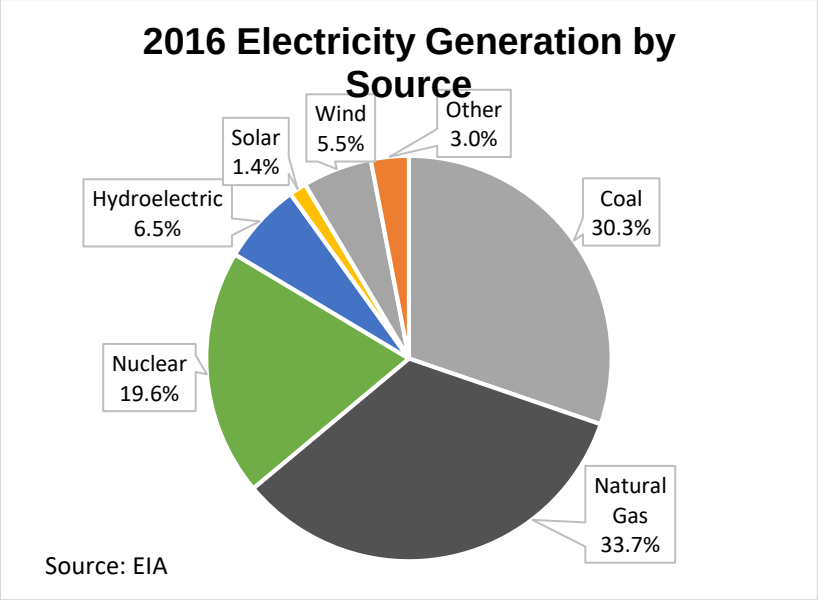
In addition, the solar industry has pumped more than $111 billion into the U.S. economy since 2000, with nearly $23 billion invested in 2016 alone. By 2021, the solar energy industry will invest another $86 billion in communities across the U.S. These investments not only put Americans to work, but represent millions of dollars in new tax revenue for state and local governments.

III. Solar is a Reliable Resource and Contributes to Grid Reliability

Recently, the value to the national electric grid of solar and other renewable energy sources has been questioned. As can be seen from the numerous studies referenced in this testimony, solar

[5] *Ibid.*
[6] U.S. Department of Energy, "U.S. Energy and Employment Report," January 2017. *Available at* https://energy.gov/downloads/2017-us-energy-and-employment-report.

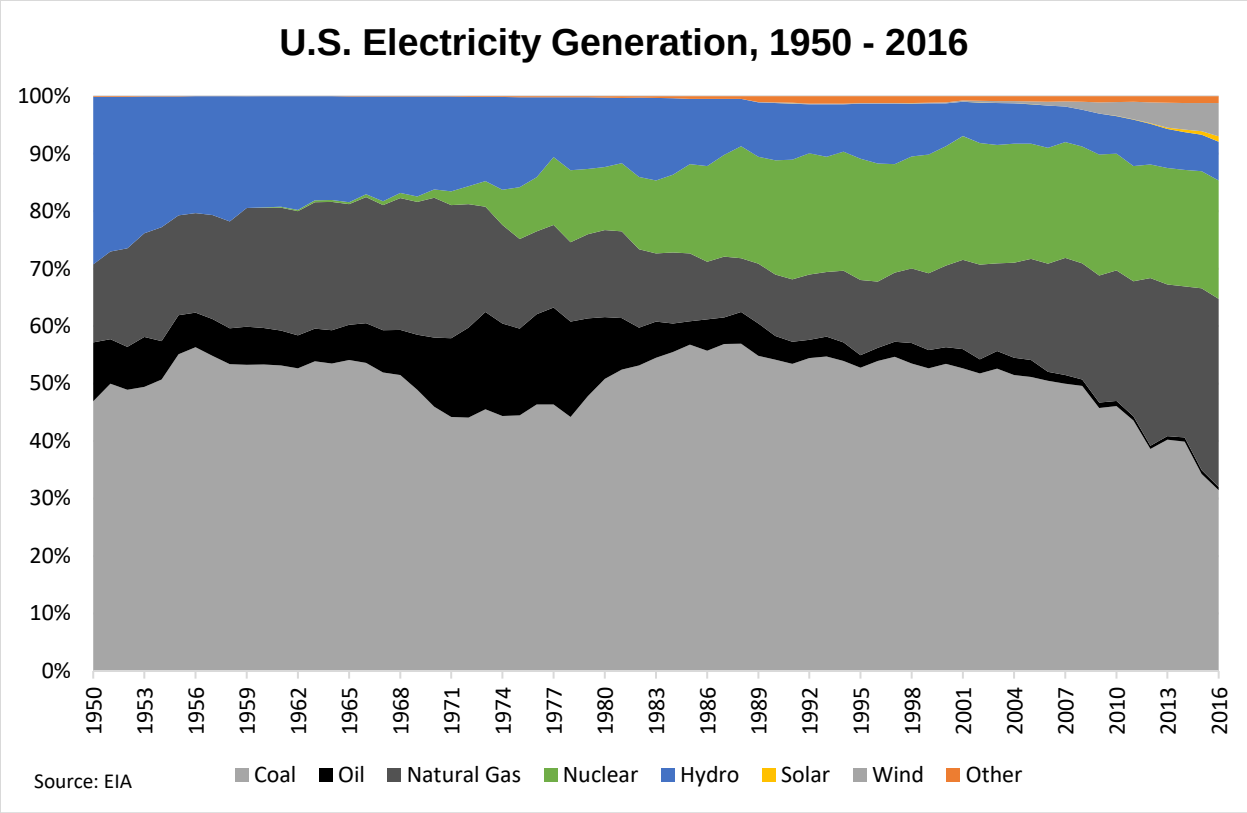
and renewables provide significant benefits to the grid in terms of reliability, fuel diversity, and security.



The U.S. electric grid has never had a more diverse array of generating resources (see chart above). According to the Energy Information Administration (EIA), in 2016 34% of U.S. electric generation came from natural gas, 30% from coal, 20% from nuclear, 9% from non-hydro renewables and 7% from other sources.[7] 2015 marked the first year ever in which 7 distinct technologies generated at least 0.5% of the nation's electricity. Similarly, grid operator PJM recently calculated that 2016 featured the most diverse electricity mix in the nation's history using a Shannon-Wiener index.[8] (not pictured)

[7] U.S. Energy Information Administration data, *available at* https://www.eia.gov/electricity/data.php

[8] PJM Interconnection, "Appendix to PJM's Evolving Resource Mix and System Reliability," March 30, 2017, page 1. *Available at* http://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-appendix-to-pjms-evolving-resource-mix-and-system-reliability.ashx.



In addition to providing fuel diversity, multiple studies from the Department of Energy's National Renewable Energy Laboratory (NREL) have shown that the existing grid can handle high penetrations of renewable energy without compromising reliability and performance. In both its Western Wind and Solar Integration Study and Eastern Renewable Generation Integration Study, NREL finds that the existing western and eastern electric grids can accommodate upwards of 30% of solar and wind power without requiring extensive infrastructure investments.[9] An additional study from NREL finds that "renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050."[10]

Additional study of the Western grid led to NREL's finding that any maintenance costs created by a need to cycle fossil-fuel plants to accommodate wind and solar generation are more than

[9] NREL, Western Wind and Solar Integration Study (2010), *available at* http://www.nrel.gov/docs/fy10osti/47434.pdf and NREL, Eastern Renewable Generation Integration Study (2016), *available at* http://www.nrel.gov/docs/fy16osti/64472.pdf.

[10] NREL, Renewable Electricity Futures Study (2012), *available at* https://www.nrel.gov/analysis/re-futures.html.

offset by the fuel savings associated with those resources.[11] Phase three of the same study demonstrated that reliability of the western grid can be maintained at high renewable penetration rates in the face of large system disturbance (such as the loss of a fossil plant).[12]

Grid operators across the country have found that reliability on the grid can be maintained at higher penetrations of renewables. The California Independent System Operator (CAISO), which manages the most solar resources in the country, finds that the state will have no issues in maintaining reliability while hitting its 33% renewables target by 2020.[13] PJM, which operates much of the eastern grid in the U.S., found in a 2014 study that it would not encounter reliability issues with 30% of their energy coming from solar and wind.[14]

Solar is Reliable Alone and Paired with Other Resources

In a joint study conducted by NREL, CAISO, and First Solar, researchers found that solar photovoltaic power plants – equipped with commercially available inverter technology – can offer "electric reliability services similar, or in some cases superior to, conventional power plants."[15] Specifically, the solar power plant can provide regulation, voltage support and frequency response during various operation modes. The tables below show the PV plant's ability to accurately respond to CAISO energy management signals, compared to other generation sources. Likewise, Concentrating Solar Power plants (CSP), which produce electricity by using the sun to heat boilers and spin turbines, are easily paired with thermal energy storage and provide a host of grid benefits that allow them to function like any fossil fuel plant.

[11] NREL, Western Wind and Solar Integration Study, Phase 2 (2013), *available at* http://www.nrel.gov/docs/fy13osti/55588.pdf.

[12] NREL, Western Wind and Solar Integration Study, Phase 3 (2014), *available at* http://www.nrel.gov/docs/fy15osti/62906.pdf.

[13] California Public Utilities Commission, Beyond 33% Renewables: Grid Integration Policy for a Low-Carbon Future (2015), *available at* http://www.cpuc.ca.gov/General.aspx?id=8982.

[14] General Electric International, Inc., PJM Renewable Integration Study (2014), *available at* http://www.pjm.com/committees-and-groups/subcommittees/irs/pris.aspx.

[15] NREL, Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant (2017) *available at* http://www.nrel.gov/docs/fy17osti/67799.pdf.

Table 2. Measured Regulation Accuracy by 300-MW PV Plant

Time Frame	Measured Accuracy of Solar PV Plant
Sunrise	93.7%
Middle of the day	87.1%
Sunset	87.4%

Table 3. Typical Regulation-Up Accuracy of CAISO Conventional Generation

	Combined Cycle	Gas Turbine	Hydro	Limited Energy Battery Resource	Pump Storage Turbine	Steam Turbine
Regulation-Up Accuracy	46.88%	63.08%	46.67%	61.35%	45.31%	40%

In combination with battery storage, solar has proven to be an easily dispatchable asset at times in which the grid fails. Programs like the SunSmart Emergency Shelter program in Florida have added solar and storage solutions to hundreds of schools and emergency shelters, offsetting everyday electricity costs and establishing a reliable source of electricity in the event of a grid failure.

Solar's ability to be used as a distributed resource has important implications for grid security. With smarter grid technology and advanced power electronics, grid operators can reallocate electrons from individual rooftop systems to where they are most needed in the face of disturbances to other generating units. Distributed systems can be paired with storage and turned into resilient microgrids. According to former CIA director James Woolsey, such microgrids could prevent "a single failure from cascading into a catastrophe."[16]

One of the biggest users of renewable energy in the U.S. is the military, which values solar for its portability and dispatchability. Solar use on the battlefield and at sea reduces to need for sometimes dangerous and costly fuel resupplies, while solar at a military base reduces electricity costs and, when paired with storage, creates a resilient energy environment in the form of a micro-grid.

[16] Woolsey, R. James, Rachel Kleinfeld, and Chelsea Sexton, "No Strings Attached: The Case for a Distributed Grid and a Low-Oil Future," *World Affairs Journal*, September/October 2010. *Available at* http://www.worldaffairsjournal.org/article/no-strings-attached-case-distributed-grid-and-low-oil-future.

Southern California Fire Caused Nearly 1,200 MW of Solar to Trip Offline

In August 2016, a wildfire around in Southern California caused several transmission lines to fault, which in turn caused a loss of PV output. The largest disruption of the day caused solar generators' inverters to trip and cease delivering electricity to the grid. When the solar inverters tripped, approximately 1,200 megawatts of electricity were lost. A joint task force comprised of NERC and the Western Electricity Coordinating Council (WECC) investigated the incident issued a report[17] earlier this year.

The investigation found that the loss of generation was due to the inverters perceiving a low-frequency condition and low-voltage blocking of the inverters. In response to either condition, the inverters are programmed to "trip," cease delivering electricity to the grid, and resume delivering electricity five minutes later. As designed, the NERC-WECC report found that "approximately 66 percent of the generation lost recovered within about five minutes."[18]

The solar energy industry and utilities worked with inverter manufacturers to make modifications to ensure that these resources have sufficient "ride-through" capability during low system frequency conditions. In addition, IEEE Standard 1547, which applies to inverters connecting to the distribution system, is currently under revision. Changes are expected to prevent similar voltage and frequency issues for solar on the distribution grid.[19] The NERC-WECC report also recommends reviewing NERC Reliability Standard PRC-024-2, a standard that details voltage and frequency relay settings for generation connected to the bulk electric system, to better consider inverter behavior.

Evolution of standards and operating procedures is not unusual when increasing use of new technologies. For example, when wind technology was believed to be subject to voltage irregularity, manufacturers developed new-generation turbines that possessed low-voltage ride-through capability. The DOE Grid Study notes that "manufacturers have designed electronic controls for newer model wind turbines that can provide automatic generation

[17] North American Electric Reliability Corporation (NERC), "1,200 MW Fault-Induced Solar Photovoltaic Resource Interruption Disturbance Report," (June 8, 2017); See, http://www.nerc.com/pa/rrm/ea/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_/1200_MW_Fault_Induced_Solar_Photovoltaic_Resource_Interruption_Final.pdf

[18] *Ibid,* p. 2

[19] Institute of Electrical and Electronics Engineers (IEEE), "IEEE P1547 Draft Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces (full revision of IEEE Std 1547);" See, http://grouper.ieee.org/groups/scc21/1547_revision/1547revision_index.html

control, primary frequency response and synthetic inertia" (page 73). Reviewing and improving inverter standards is consistent with one of the DOE Grid Study policy recommendations:

> "**Promote Research and Development (R&D) of next-generation/21st century grid reliability and resilience tools:** DOE should focus R&D efforts to enhance utility, grid operator, and consumer efforts to enhance system reliability and resilience …
>
> - Focus R&D on improving VRE integration through grid modernization technologies that can increase grid operational flexibility and reliability through a variety of innovations in sensors and controls, storage technology, grid integration, and advanced power electronics. The Grid Modernization Initiative should also consider additional applications of high-performance computing for grid modeling to advance grid resilience." P. 126

The August 21, 2017 Solar Eclipse Caused No Reliability Issues

On Monday, August 21, 2017, a total solar eclipse passed over the continental United States, affecting solar output. Researchers at the Electric Power Research Institute (EPRI) spent the day monitoring solar energy production across the country, culminating in a recently-released report.[20] The reliability lessons learned from the eclipse were not surprising: solar PV systems with 99% or less eclipse coverage remained connected to the grid, with only two monitored PV systems shutting down for a few minutes during the event.

The impact of the eclipse on California grid reliability was the most instructive because California has six times more solar electric capacity than any other state. There, the eclipse took 3,000 megawatts of utility-scale and rooftop solar off the grid.[21] Grid operators had to deal with two solar ramp-ups, instead of just one. According to *RTO Insider, the "*CAISO had to manage not only the rapid loss of solar but also a steeper-than-usual climb of that resource compared with a normal day as the sun returned. CAISO predicted it would lose about 51 MW/minute, and as the blockage waned, solar generation came back at a rate of 93 to 100 MW/minute. On a normal morning, solar ramps about 29 MW/minute."[22]

To maintain grid reliability, the CAISO ramped up hydro and natural gas generation as solar dropped off, then did the reverse as solar generation returned. CAISO, typically a net exporter,

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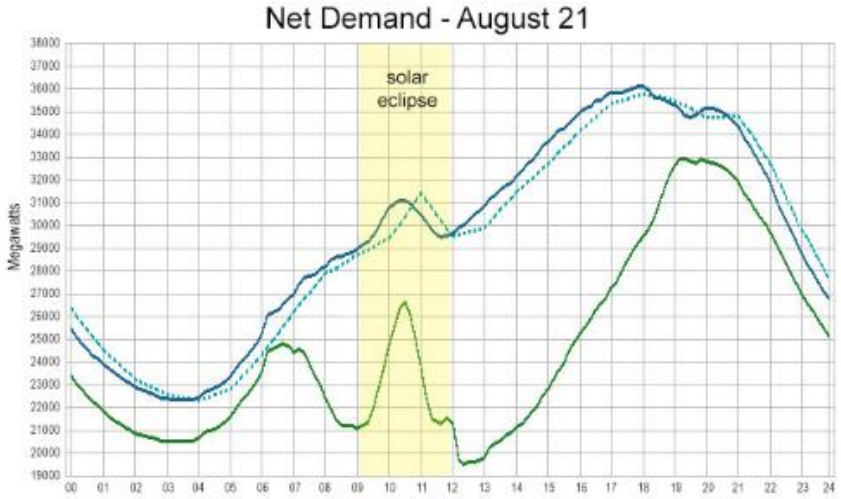
[20] Electric Power Research Institute, "Solar Siesta: Photovoltaic Generation and the Great American Eclipse," (September 4, 2017); See, https://www.epri.com/#/pages/product/000000003002011693/.

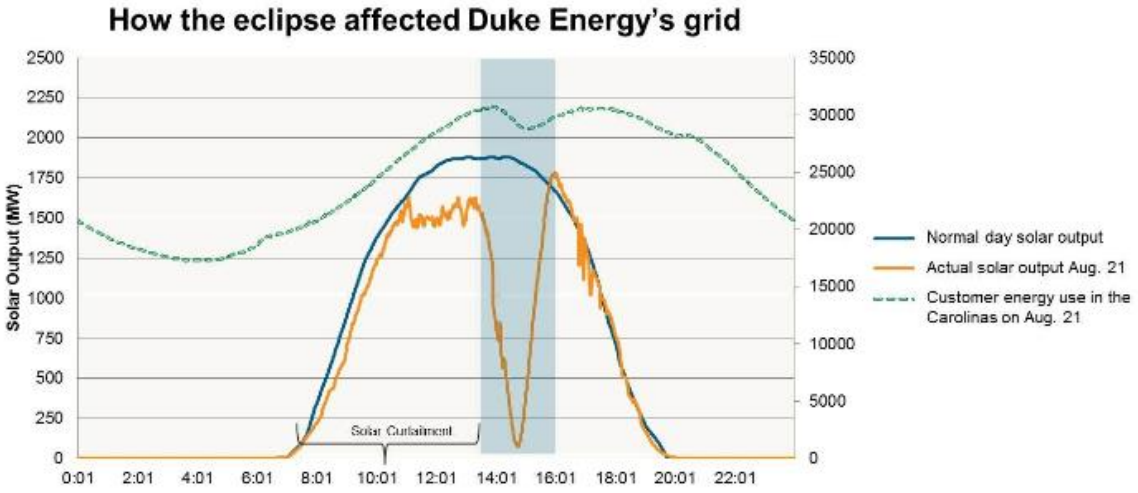
[21] CAISO, "Managing the Eclipse," (August 21, 2017); See, http://www.caiso.com/informed/Pages/SolarEclipse/Default.aspx.

[22] Jason Fordney, Tom Kleckner, Amanda Durish Cook, Rory D. Sweeney and Michael Kuser (RTO Insider), "Grid Operators Manage Solar Eclipse," (August 21, 2017); See, https://www.rtoinsider.com/rtos-solar-eclipse-grid-operators-48180/.

also used power from the Energy Imbalance Market, a wholesale market made up of utilities in several states that allows entities to buy and sell power within the hour it's needed.



In North Carolina, which is currently second in the nation for installed solar capacity, the eclipse took place in the early afternoon, normally a peak time for solar energy production. Duke Energy lost about 1,700 of its 2,500 MW solar capacity during the eclipse, but other resources like natural gas plants were used to fill the void.[23]



In short, grid operators across the country reported no major reliability issues, even as solar output dipped on the day of the eclipse. Grid operators' ability to accurately forecast solar

[23] Jessica Wells (Illumination/Duke Energy), "What happened to solar energy during the eclipse?," August 23, 2017. *Available at* https://illumination.duke-energy.com/articles/what-happened-to-solar-energy-during-the-eclipse.

production led this rare astronomical event to be a non-event for grid reliability.

DOE's Proposed "Grid Resiliency Rule"

Last week the Secretary of Energy sent to the Federal Energy Regulatory Commission (FERC) a proposed rule to address grid resiliency through cost-based payment mechanisms for coal and nuclear power plants that are (a) physically located within the boundaries of a Regional Transmission Organization (RTO) or Independent System Operator (ISO) and (b) have at least a 90-day fuel supply onsite.[24] The Secretary cites a need to "protect the American people from the threat of energy outages that could result from the loss of traditional baseload capacity"[25] and specifically identifies "the ability to provide voltage support, frequency services, operating reserves, and reactive power" as benefits that such generation resources bring to the grid.

SEIA supports the overarching theme of the Secretary's letter: FERC should continue its important work on price formation. We also agree with the assertion that generators – all generators – should be fully compensated for the energy, capacity, and ancillary services they provide to the grid. However, this rushed rulemaking is not the right way to achieve these ends. FERC can and should define any reliability services or products that are missing from the marketplace in a technologically-neutral manner. In competitive markets, such as those operated by RTOs and ISO, sellers should provide and price those services according to buyers' willingness to procure those products. Healthy competition will yield the most innovative solutions at the lowest prices to consumers.

IV. Solar is a Low-Cost Option Around the Country

Solar is an energy source available in every U.S. Congressional district. Because most of the cost of a solar installation is up front and no additional fuel cost is needed to operate, solar plays a key role in hedging against rising fossil fuel prices. Building on earlier research, NREL found in a 2013 study that adding solar and wind to an electricity resource portfolio at penetration rates up to 40% significantly reduces exposure to variability in fossil fuel costs.[26]

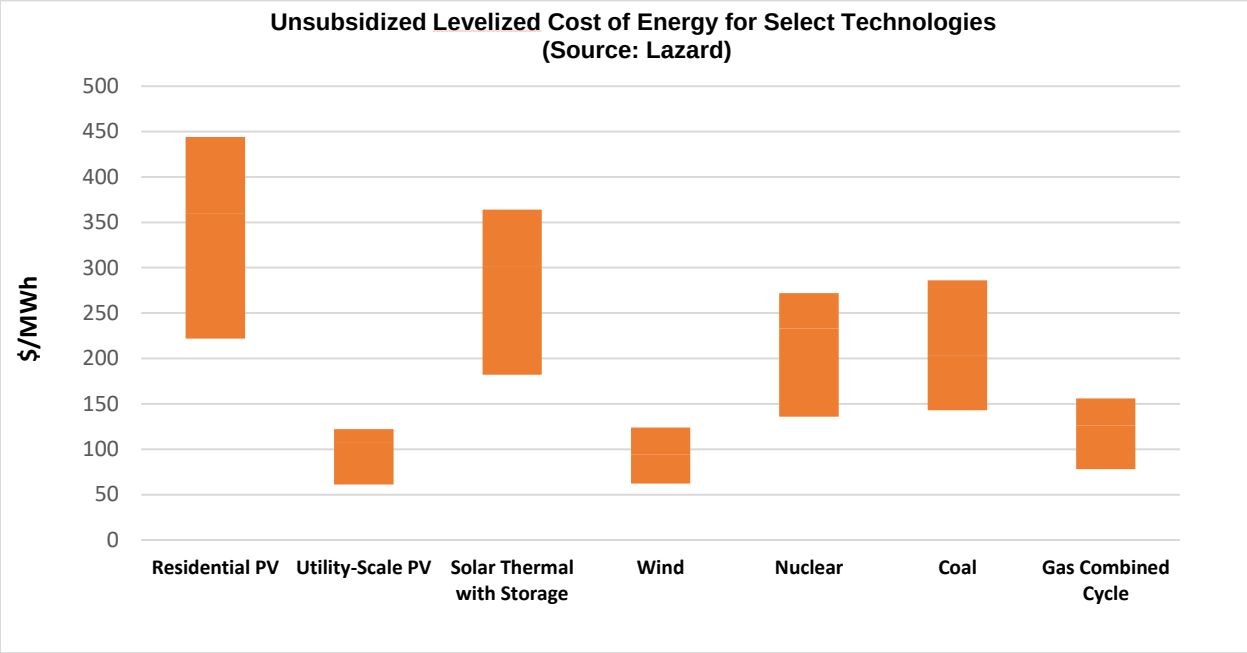
According to Lazard, a leading financial advisory and asset management firm, while the Levelized Cost of Electricity (LCOE) for generation from new coal plants has remained around

[24] See letter filed in Docket No. RM18-1-000, available at https://elibrary.ferc.gov/idmws/common/opennat.asp?fileID=14696057 (Sept. 28, 2017).

[25] *Ibid*, p. 1.

[26] NREL, The Use of Solar and Wind as a Physical Hedge against Price Variability within a Generation Portfolio, (2013), *available at* http://www.nrel.gov/docs/fy13osti/59065.pdf.

$100/MWh over the past 5 years, the LCOE for electricity from natural gas plants has dropped from $75/MWh to $63/MWh. Lazard finds the unsubsidized levelized cost of utility-scale solar now ranges from $46 to $92/MWh, on par with wholesale electricity from new wind and natural gas plants. Residential solar, which competes against retail electricity prices, is now competitive in most markets. Innovations in system financing have opened up the residential and commercial solar marketplace to more consumers than ever before, giving all Americans the opportunity to go solar.[27]

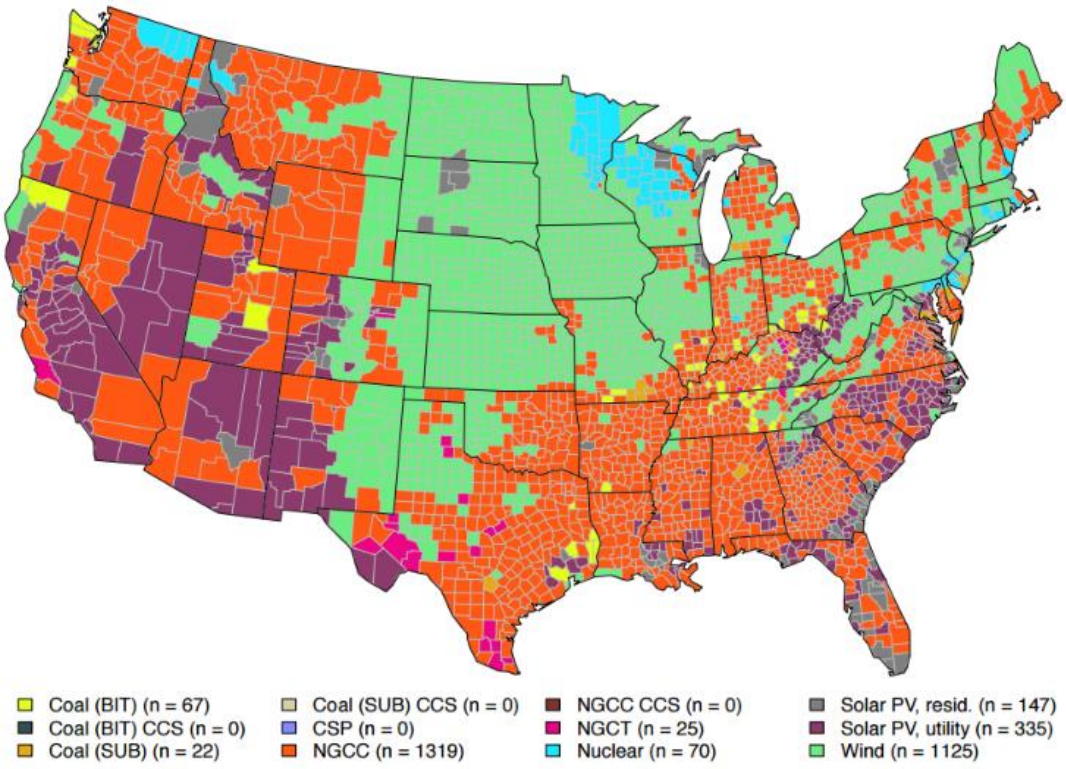


A new study from the University of Texas shows that natural gas and unsubsidized wind and solar power are the cheapest source for new generation capacity in 95% of counties nationwide.[28] This is primarily due to the steep decline in the price to install a solar energy system, which has dropped by nearly 70% in the last 5 years.

[27] Lazard, Levelized Cost of Energy Analysis, 10.0 (2016), *available at* https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/.
[28] University of Texas at Austin Energy Institute, New U.S. Power Costs: by County, with Environmental Externalities (2016), *available at* http://energy.utexas.edu/the-full-cost-of-electricity-fce/fce-publications/lcoe-white-paper/.

FIGURE 8

Scenario 4: Minimum cost technology for each county, including availability zones, but not including externalities (Equation 1) with reference case assumptions from Table 1.



V. Making the Most of the Nation's Exceptional Solar Assets: Policy Recommendations

As shown throughout this testimony, solar energy is a key component of the nation's energy mix. New solar installations receive a federal investment tax credit (ITC), currently 30 percent of the project's investment costs. The solar ITC is scheduled to phase out over the next four years, reducing to a 10 percent credit for systems owned by a business and no tax credit for systems owned by an individual taxpayer beginning in 2022. While Congress undertakes the complex and challenging task of comprehensive tax reform, we urge it to maintain the current phase-down schedule for the solar ITC. A stable, predictable tax policy for solar energy allows sound investment decisions to be made, furthering the growth of the industry.

The solar industry is currently engaged in a Section 201 "global safeguard" case at the International Trade Commission. Two companies with a small manufacturing presence in the U.S., both subsidiaries of foreign firms, filed a case with the International Trade Commission (ITC) seeking import tariffs that would stifle competition and dramatically increase the price of solar cells and modules. Import duties would be a disaster for the American economy and

would jeopardize 88,000 jobs in the U.S. solar industry, including domestic solar manufacturing jobs. Nonetheless, SEIA is interested in pursuing innovative solutions that support American solar cell and module manufacturing while preserving American jobs and the solar success story. Today (October 3, 2017) the International Trade Commission is holding its "remedy hearing" wherein proposals for tariff and non-tariff remedies will be considered. The ITC will issue its recommendation in mid-November. We oppose any tariff that would restrict the flow of freely- and fairly-traded goods.

We support federal energy policies that promote reliability, security and fuel diversity. S. 1460, the *Bipartisan Energy and Natural Resources Act of 2017* takes important steps in this direction. Increased transmission investment will bring greater reliability and access to more diverse sources of generation. In addition, we look to FERC to ensure that well-functioning wholesale electric markets promote thrive and, in parts of the country without RTOs and ISOs, to guarantee open-access and non-discriminatory treatment for independent renewable generators. Finally, incentivizing energy storage deployment on the transmission and distribution grids will increase grid reliability and provide another dispatchable resource to system operators.

VI. Conclusion

Thank you once again for inviting SEIA to submit this testimony. SEIA is grateful for the tremendous public support that solar has across the nation, which is reflected in the great interest and extensive efforts of this Committee. We look forward to working with the Committee to establish the long-term, stable policies needed to make the most of America's exceptional solar assets, delivering solar's benefits to the nation in the form of large quantities of cost-effective, clean and sustainable power, growing numbers of jobs throughout the country, and outstanding economic opportunity.