BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

Petition of PPL Electric Utilities Corporation for Approval of Tariff Modifications and Waivers of Regulations Necessary to Implement its Distributed Energy Resources Management Plan	: : : : :	Docket No. P-2019-3010128

REBUTTAL TESTIMONY OF WANDA REDER

PPL Electric Statement No. 2-R

March 4, 2020

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Wanda Reder, and my business address is 34W676 Country Club Road, Wayne, Illinois 60184.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am the President and CEO of Grid-X Partners, LLC ("Grid-X").

Q. HAVE YOU PREVIOUSLY SUBMITTED IN DIRECT TESTIMONY IN THIS PROCEEDING?

A. Yes. My direct testimony is set forth in PPL Electric Statement No. 2.

Q. WHAT IS THE PURPOSE OF YOUR REBUTTAL TESTIMONY?

A. I will respond to some of the allegations and recommendations made in: NRDC Statement No. 1, the Direct Testimony of Harry Warren submitted on behalf of the Natural Resources Defense Council ("NRDC"); OCA Statement No. 1, the Direct Testimony of Ron Nelson submitted on behalf of the Office of Consumer Advocate ("OCA"); SEF Statement No. 1 (Non-Proprietary), the Direct Testimony of John Costlow submitted on behalf of the Sustainable Energy Fund ("SEF"); and SEF Statement No. 2, the Direct Testimony of Ron Celentano submitted on behalf of SEF.

My rebuttal testimony addresses the following topics: (1) the timeframes for Institute of Electrical and Electronics Engineers ("IEEE") 1547.1, Underwriters Laboratories ("UL") 1741, and when smart inverters compliant with IEEE 1547-2018 will be commercially available; (2) whether PPL Electric's Distributed Energy Resource

("DER") Management proposal is consistent with IEEE 1547-2018; (3) the resolution recently passed by the National Association of Regulatory Utility Commissioners ("NARUC"), which recommends that state utility commissions take action now to adopt and implement IEEE 1547-2018; and (4) other parties' assertions about DER penetration levels in the Company's service territory as compared to other states.

Q. ARE YOU SPONSORING ANY EXHIBITS WITH YOUR REBUTTAL TESTIMONY?

A. Yes. Attached to my rebuttal testimony are PPL Electric Exhibits WR-1R through WR-3R. They are as follows:

- PPL Electric Exhibit WR-1R – IEEE's timeline for rollout of IEEE 1547.1 and UL 1741 as updated in January 2020; and
- PPL Electric Exhibit WR-2R – A copy of NARUC's recently-passed resolution to act on and adopt IEEE 1547-2018;
- PPL Electric Exhibit WR-3R – The December 2019 edition of the "U.S. Solar Market Insight" publication by Wood Mackenzie Power & Renewables, Inc. d/b/a Greentech Media and the Solar Energy Industries Association ("SEIA").

I. TIMEFRAMES FOR IEEE 1547.1, UL 1741, AND WHEN SMART INVERTERS COMPLIANT WITH IEEE 1547-2018 WILL BE COMMERCIALLY AVAILABLE

Q. IN YOUR DIRECT TESTIMONY, YOU PROVIDED SOME ANTICIPATED TIMEFRAMES FOR WHEN IEEE 1547.1 AND THE REVISIONS TO UL 1741 MAY BE PUBLISHED. DO YOU HAVE ANY UPDATES?

A. In my direct testimony, I stated that IEEE 1547.1 is currently under revision, has gone to ballot, and is expected to be approved early in 2020. (PPL Electric Statement No. 2, p. 8, lines 7-8.) I also stated that "[b]ased upon the recent update of IEEE Standard 1547 in 2018, UL Standard 1741 is currently under revision, with an expected release sometime in the first half of 2020." (PPL Electric Statement No. 2, p. 7, lines 9-10.)

Some time has passed since my direct testimony was filed and as such, development has progressed and the certainty for when standards will be complete has increased. A timeline that was updated in January 2020 by the IEEE Standards Association for the rollout of IEEE 1547.1 and UL 1741 is included as PPL Electric Exhibit WR-1R. As stated in that document, approval of IEEE 1547.1 is expected in early March 2020, with publication anticipated to occur in April or May of 2020. The UL Standard 1741 is currently under revision and will contain a Supplement SA and a new Supplement SB, which points to the test requirements in 1547.1-2020. Because IEEE and UL have been closely coordinating, the approval of UL 1741 is expected to be relatively straightforward and is forecasted to be complete in the second or third quarter of 2020.

Q. NRDC WITNESS WARREN AND OCA WITNESS NELSON HAVE PRESENTED ESTIMATED TIMEFRAMES FOR WHEN SMART INVERTERS COMPLIANT WITH IEEE 1547-2018 WILL BE COMMERCIALLY AVAILABLE. (NRDC ST. NO. 1, P. 10; OCA ST. NO. 1, PP. 9, 28.) COULD YOU PLEASE RESPOND?

A. Both NRDC witness Warren and OCA witness Nelson contend that smart inverters that` meet IEEE 1547-2018 will be commercially available by January 1, 2022. (*See* NRDC St.

No. 1, p. 10; OCA St. No. 1, p. 28.) Also, OCA witness Nelson asserts that it will take "approximately 18 months" after the revisions to IEEE 1547.1 and UL 1741 are published before all DER products conform with IEEE 1547-2018. (OCA St. No. 1, p. 9.). However, Mr. Nelson fails to mention that "approximately 18 months" after the revisions to the standards are published is when all compliant smart inverters are expected to be commercially available. As can be seen in the Timeline for rollout in PPL Electric Exhibit WR-1R, compliant smart inverters are expected to be certified and available in the market as soon as the fourth quarter of 2020. This is due to certain manufacturers preparing for IEEE 1547-2018 and the revised UL 1741 by participating in standards development and by innovating and demonstrating capability in parallel. These efforts have positioned certain manufacturers to have products that already have the required functionality and can be commercially available as soon as the new standards are finalized, and UL certification is received. Because manufacturers are at different stages of development and because it will take some time for UL to test and validate all inverters, the dates that certified equipment will be available in the marketplace will vary by manufacturer. The early commercial releases of compliant smart inverters, which are expected before the end of 2020, will be available to be used upon approval of PPL Electric's DER Management Petition.

Q. SEF WITNESS CELENTANO AVERS THAT "THE UL1741 SA STANDARD MAY NOT SYNCHRONIZE WITH THE REVISED IEEE 1547-2018 UNTIL 2021." (SEF ST. NO. 2, P. 6.) WOULD YOU PLEASE RESPOND?

A. UL1741 SA is not intended to fully synchronize with IEEE 1547-2018 because it does not include all of the functionality and it does not certify communications. As explained previously, the UL 1741 is currently under revision and will contain a Supplement SA and a new Supplement SB, which will reference the test requirements in 1547.1-2020. Because IEEE and UL have been closely coordinating, the approval of UL 1741 is expected to be relatively straightforward and is forecasted to be complete in the second or third quarter of 2020, at which time UL 1741 Supplement SB will fully synchronize with IEEE 1547-2018. (*See* PPL Electric Exhibit WR-1R.)

II. PPL ELECTRIC'S DER MANAGEMENT PROPOSAL IS CONSISTENT WITH IEEE 1547-2018

Q. ACCORDING TO OCA WITNESS NELSON, PPL ELECTRIC'S DER MANAGEMENT PETITION "CONFLATES THE SMART INVERTER REQUIREMENTS SET FORTH IN IEEE 1547-2018 AND UL 1741 CERTIFICATION STANDARDS WITH UTILITY CONTROL OF CUSTOMER-SITED DER." (OCA ST. NO. 1, PP. 18-28.) DO YOU AGREE WITH HIS POSITION?

A. No. PPL Electric's DER Management proposal is consistent with IEEE 1547-2018. As explained in my earlier testimony (PPL Electric Statement No. 2-R), IEEE 1547-2018 requires smart inverters to have two channels for communications. PPL Electric's DER Management proposal would allow the Company to utilize one of the communication channels that is a dedicated local DER interface specified to exchange nameplate, configuration, monitoring and management information as defined in Section 10.2 and 10.7 of IEEE 1547-2018. This capability provides the wherewithal to monitor and manage the DER in order to maintain power quality and reliability and also mitigate the impact DERs have on the grid. Therefore, PPL Electric's proposal to utilize a communications channel to monitor and manage the DERS is expressly contemplated by the requirements of IEEE 1547-2018.

Q. OCA WITNESS NELSON ALSO ALLEGES THAT PPL ELECTRIC'S DER MANAGEMENT PROPOSAL "DEVIATES" FROM IEEE 1547-2018'S DEFAULT SPECIFICATIONS BY REQUIRING A FIXED POWER FACTOR THAT IS DIFFERENT FROM THE DEFAULT 1.0 POWER FACTOR AND BY ENABLING THE COMPANY TO ACTIVATE THE VOLT/VAR FUNCTION. (OCA ST. NO. 1, PP. 13-14.) WOULD YOU PLEASE RESPOND?

A. Under PPL Electric's DER Management proposal, power factor of the DER does have the potential to deviate from 1.0 or unity when voltage at the DER is deviating outside the set dead-band in the Volt/Var curve, as explained in Mr. Salat's Rebuttal Testimony (PPL Electric Statement No.1-R). It is important to note that IEEE 1547-2018 is designed and written to be functionally flexible. The standard does not unilaterally mandate how DER equipment or components shall be designed. IEEE 1547-2018 also avoids specifications governing "how" the DERs shall provide grid support. For example, the standard does not provide specifications on voltage and frequency ride-through settings or other grid support functions. While all DER must have the capability as defined in IEEE 1547-2018 to implement defined functions, whether or not any of these functions are required to be activated in any specific deployment is up to the discretion of the operator. This flexibility in IEEE 1547-2018 is essential because there are many different distribution operating practices that can vary significantly based on existing local grid designs, conditions, and practices. A few examples of variability in distribution practices include the use of capacitors, regulators, load tap changers, distribution automation, as well as physical and electrical characteristics such as length of circuit, loading of circuit, voltage, and contingency built into the design that facilitates reconfiguration. Beyond design, there are increasingly severe weather events, declining inertia, and emergent conditions that contribute to variability and abnormalities. The IEEE 1547-2018 requirements are also cognizant that different DER interconnection technologies have differing technical capabilities so the requirements in the standard have been established so they are transparent and fair to be used across a broad categorization of technologies.

III. NARUC'S RESOLUTION ON STATE UTILITY COMMISSIONS' IMPLEMENTATION OF IEEE 1547-2018

Q. NRDC WITNESS WARREN RAISED NARUC'S DRAFT RESOLUTION ON IMPLEMENTATION OF IEEE 1547-2018 IN HIS DIRECT TESTIMONY. (NRDC ST. NO. 1, P. 16; NRDC EXH. C.) COULD YOU PROVIDE SOME BACKGROUND ON THE DEVELOPMENT OF THIS DRAFT RESOLUTION?

A. Yes. In September 2019, I was a speaker for a NARUC-NIST[1] Interoperability Workshop. New smart inverter technology was presented to regulators along with the increasing complexity of the grid, the need for an overarching architecture/integration, and the importance of adopting the new IEEE 1547-2018 and its sister testing standard,

[1] NIST stands for the National Institute of Standards and Technology.

IEEE 1547.1. A few states had started to act to adopt the new IEEE standard; however, most attendees were interested in learning how to proceed and understanding what questions to ask. To encourage state regulators to act, NARUC issued a draft resolution on January 23, 2020, which, if passed, would encourage state regulators to adopt and implement the latest IEEE 1547-2018 standard on interconnection to expand DERs and take advantage of the smart inverters' grid support functions.

Q. SINCE NRDC SUBMITTED ITS DIRECT TESTIMONY, HAS NARUC PASSED A FINAL VERSION OF THE RESOLUTION?

A. Yes. NARUC's Board of Directors approved a final version of the resolution on February 12, 2020. Attached to my rebuttal testimony as PPL Electric Exhibit WR-2R is a copy of NARUC's resolution.

Q. DO YOU BELIEVE THAT NARUC'S RESOLUTION PROVIDES FURTHER SUPPORT FOR THE COMPANY'S DER MANAGEMENT PETITION?

A. Absolutely. The NARUC resolution calls for state regulators to take action now before too many DERs are deployed without IEEE 1547-2018-compliant inverters. The arguments that were presented leading to the resolution recognize that many states, like Pennsylvania, are experiencing the installation and interconnection of DERs and that if they are "interconnected and operated in a safe and reliable manner," the DERs "can offer economic, reliability, resilience, and environmental benefits to consumers, communities and utilities." (PPL Electric Exhibit WR-2R, p. 1.) This is precisely the objective of the DER Management Petition. Furthermore, the resolution notes that there is benefit from timely adopting “rigorous, clear, up-to-date standards for safe and reliable interconnection, integration and parallel operation of DERs,” specifically citing the updated IEEE 1547-2018 standard that “will transform how DERs interact with and function on the electric distribution system.” (PPL Electric Exhibit WR-2R., p. 1.) PPL Electric’s DER Management Petition has been developed with the full intent to utilize this updated IEEE standard.

The NARUC resolution also recognizes that “IEEE 1547-2018 requires DERs to be capable of performing specific grid support functions related to voltage, frequency, communications, and controls” so that “increasing levels of DERs are reliable at both the distribution and bulk power system levels” and “can be visible to grid operators.” (PPL Electric Exhibit WR-2R, p. 1.) Through the approval of the DER Management Petition, PPL Electric seeks to have its customers and its distribution system reap this benefit.

In addition, the resolution advocates for the need to implement IEEE 1547-2018 before “new DERs” are “connected to the grid using legacy technical requirements and standards that will prevail for the duration of the DER’s lifetime.” (PPL Electric Exhibit WR-2R, p. 1.) Therefore, parties need to act now, especially because there are “significant logistical and legal barriers” to “modifying DER interconnection requirements post-installation.” (PPL Electric Exhibit WR-2R, p. 1.) Again, PPL Electric has been trying to proactively implement IEEE 1547-2018 and get ahead of the issues before more non-smart inverters are interconnected with the Company’s distribution system. Every new DER interconnection that is not equipped with a compliant smart inverter and DER Management device is an opportunity lost.

Further, the NARUC resolution anticipates that there will be "widespread availability" of equipment compliant with IEEE 1547-2018 in the 2021 timeframe, which is precisely one of the reasons that the PPL Electric is acting now. (*See* PPL Electric Exhibit WR-2R, p. 2.)

I also observe that NARUC has recognized that many other organizations are aligned and supportive of this resolution, noting that the North American Electric Reliability Corporation ("NERC") in its draft Reliability Guideline, "Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018" encourages State regulators to "support early implementation of IEEE 1547-2018 and begin engaging with necessary stakeholders." (PPL Electric Exhibit WR-2R, p. 2.) NARUC's resolution also states that IEEE, Electric Power Research Institute, National Renewable Energy Laboratory, Regulatory Assistance Project, Interstate Renewable Energy Council, NERC, National Rural Electric Cooperative Association and others have compiled excellent resources to support state commissions on IEEE 1547-2018 implementation based on evidence and research. (*See* PPL Electric Exhibit WR-2R, p. 2.)

In sum, NARUC approved the resolution to encourage state regulators and utilities to adopt and implement IEEE 1547-2018 and to integrate the standard, such as addressing issues related to technology, location, and settings of utility-owned protective elements. Therefore, PPL Electric's DER Management Petition is consistent with the goals outlined in the NARUC resolution.

IV. PPL ELECTRIC IS IDEALLY POSITIONED TO MONITOR AND MANAGE DERS

Q. NRDC WITNESS WARREN AND OCA WITNESS NELSON ALSO ARGUE THAT NO OTHER ELECTRIC UTILITY HAS BEEN GIVEN PERMISSION TO MANAGE DERS, AND SINCE OTHER STATES HAVE HIGHER LEVELS OF DERS, THEY CLAIM THAT THERE IS NO REASON FOR PPL ELECTRIC TO BE THE FIRST UTILITY MANAGING DERS. (NRDC ST. NO. 1, PP. 31-32; OCA ST. NO. 1, PP. 20-28.) DO YOU AGREE WITH THEIR POSITION?

A. No. Their position is patently wrong. In contrast to utilities in these other states, PPL Electric is ideally positioned to implement the DER Management proposal. As explained in Mr. Salet's rebuttal testimony, unlike other electric utilities who have made proposals to monitor and manage DERs, PPL Electric has invested in grid modernization technology which provides the necessary platform to implement its DER Management proposal. The Company has been and continues to be an industry leader for implementing distribution management capability to isolate faults, automate meter reading, and develop a host of operating software tools such as DMS and DERMS, which are essential and will be leveraged to execute the DER Management proposal. Furthermore, PPL Electric's use of the ConnectDER DER Management devices will make installations more efficient and economical. This technology readiness differentiates PPL from other utilities who have proposed to manage and monitor DERs without having built the necessary supporting infrastructure.

In addition, although OCA witness Nelson is correct that the Illinois Commerce Commission denied ComEd's proposal, he neglects to mention the ICC's ruling that this issue should be revisited in another proceeding and that ComEd could make its proposal to manage DERs in the future. Indeed, soon after the passage quoted on page 22, line 14 to page 23, line 4 of Mr. Nelson's direct testimony, the ICC stated the following:

> The Commission also agrees with ELPC/VS that this issue should be revisited during the Section 16-107.6(e) proceeding. Alternatively, <u>ComEd could seek Commission approval in a future proceeding should ComEd determine additional control is needed</u>.[2]

Furthermore, it is much more difficult to implement the Company's proposal or similar proposals when too many DERs without smart inverters and without DER management devices have been deployed. The best time to take action is before DER levels increase to a point where there are wide-spread system issues and reliability concerns. As I referenced in my direct testimony (PPL Electric Statement No. 2), Germany had a high penetration of PV installations and was forced to manually retrofit 300,000 DERs, which cost approximately €175 million (~$190 million). A couple of lessons we can learn from Germany is to take action before issues occur to avoid costly mitigations later and to build in flexibility to manage and monitor, recognizing that system conditions and requirements change over time.

V. <u>OTHER PARTIES' ASSERTIONS ABOUT DER PENETRATION LEVELS IN THE COMPANY'S SERVICE TERRITORY AS COMPARED TO OTHER STATES</u>

Q. OCA WITNESS NELSON AND SEF WITNESSES COSTLOW AND CELENTANO CONTEND THAT THE COMPANY'S PETITION IS PREMATURE BECAUSE DER PENETRATION LEVELS IN PPL ELECTRIC'S

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[2] *Commonwealth Edison Co.; Petition for Approval of Rider DG REBATE – Renewable Energy Distributed Generation Rebate and Rider DG REBATE ADJUSTMENT – Renewable Energy Distributed Generation Rebate Adjustment*, 2018 Ill. PUC LEXIS 1736, *118 (Ill. Comm. Comm'n Nov. 26, 2018) (emphasis added).

SERVICE TERRITORY AND PENNSYLVANIA IN GENERAL ARE NOT HIGH ENOUGH. (OCA ST. NO. 1, PP. 29-32; SEF ST. NO. 1 (NON-PROPRIETARY), PP. 5-8; SEF ST. NO. 2, PP. 6-8.) IS IT REASONABLE FOR OTHER PARTIES TO ASSUME THAT PPL ELECTRIC WILL CONTINUE ON A TRAJECTORY OF STEADY, BUT LOW LEVELS OF INCREASE IN DERS?

A. After considering trends at a national level and experiences in other states, a forecasted trajectory of steady, but low levels of increased DERs is too conservative of an outlook. While there are many nuances that impact DER growth rates, rapid growth trajectories include a rapid rise in the number and capacity of DER with net-energy metering ("NEM"). Shown below are rapidly accelerating growth rates on systems in Missouri and South Carolina. Given the experience elsewhere, a similar growth scenario in PPL Electric's service territory is well within reason.

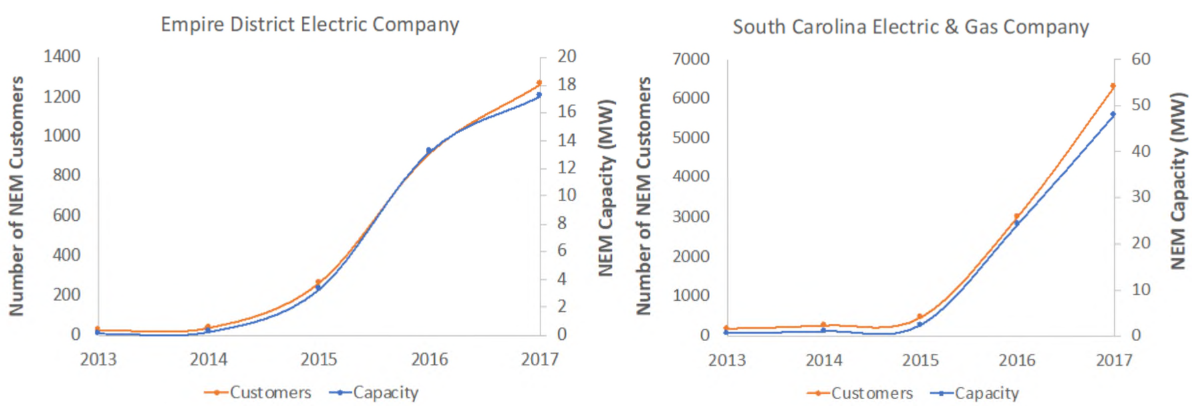

Figure 1. Examples of rapidly accelerating DPV deployment on some U.S. systems: Missouri's Empire District Electric Company and South Carolina Electric & Gas Company (EIA 2017)

Another factor that could impact an increase of DER installations in PPL Electric's service territory is a booming US solar market. After years of steady double-digit-percentage growth over the first half of this decade, the U.S. residential sector experienced growing pains in 2016-2017. In 2019 the market regained steam. In the third quarter of 2019, the U.S. residential solar market had its best quarter in history.[3] (PPL Electric Exhibit WR-3R.)

Some of the growth is attributed to falling solar prices. Exhibit WR-3R also notes that prices have been falling year-over-year by 6% or more and are now at an all-time low. As prices go down, installations increase, thereby spreading growth to a broader swath of states well beyond California, which has been the long-standing U.S. market leader. An additional 14 states had record installations at the end of 2019, including top markets like Florida and Texas and smaller emerging markets like Idaho and New Mexico. (PPL Electric Exhibit WR-3R.)

If new and established markets are seeing a boom, Pennsylvania could too. Pennsylvania was the 22nd ranking state in the U.S. in 2019 for installed solar PV installations. The Commonwealth's ranking compared to other states, has been increasing slightly year-over-year for the past three years (PPL Electric Exhibit WR-3R, p. 10). With these factors and added emphasis to generate clean energy in the Commonwealth, Pennsylvania is positioned for potential growth that certainly could exceed a steady growth trajectory.

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[3] *US Solar Market Insight Executive Summary*, Solar Energy Industries Association and Wood Mackenzie Power & Renewables, December 2019.

Q. FROM YOUR PERSPECTIVE, SHOULD THE COMPANY HAVE TO WAIT UNTIL THE SOLAR GROWTH RATE IN THE COMPANY'S SERVICE TERRITORY SUBSTANTIALLY INCREASES BEFORE IMPLEMENTING THE DER MANAGEMENT PLAN?

A. No. To the contrary, the best time to implement the proposal is when there are lower levels of DERs deployed in a service territory. That way, as DER penetration increases in the future, the utility has a much broader base of DERs that it can monitor and manage without needing to retrofit existing DER installations, which is a much more expensive and time-consuming process. This is the problem faced by utilities in states such as California and Hawaii, where too many DERs with non-smart inverters have been installed before IEEE 1547-2018 can be implemented. PPL Electric is well-positioned to maximize the number of DERs that are equipped with smart inverters that meet IEEE 1547-2018 and can provide grid support functions. Moreover, as demonstrated by Mr. Salet's rebuttal testimony (PPL Electric Statement No. 1-R) and in Dr. Karen Miu's direct testimony (PPL Electric Statement No. 3), the Company is experiencing issues with DERs on its distribution system now with the existing levels of DERs. Therefore, the timing for PPL Electric to present the DER Management Petition is impeccable, no matter if future DER growth is steady or exponential.

Thus, PPL Electric's DER Management Petition will produce substantial benefits for the Company's customers and distribution system and help foster a clean energy future. Accordingly, PPL Electric should be permitted to take action now to get ahead of the issues and implement its DER Management proposal.

Q. DOES THIS CONCLUDE YOUR REBUTTAL TESTIMONY AT THIS TIME?

A. Yes, although I reserve the right to supplement my rebuttal testimony.

PPL Electric Exhibit WR-1R

Timeline for rollout of 1547.1 and UL 1741

Dates	Activities	Status
April 2018	**Milestone:** IEEE 1547-2018 published: New DER grid interconnection requirements established. In parallel: IEEE 1547.1 update in progress. (New test procedures to verify conformance to 1547-2018)	Complete
February 26-27, 2019	IEEE P1547.1 WG meeting – Draft 9.3 approved by Working Group	Complete
March 2019	Final pre-ballot edits to P1547.1	Complete
April 2019	**Milestone:** Final WG vote to send P1547.1 Draft 9.4 to IEEE-SA	Complete
April 2019	P1547.1 D9.4 sent to IEEE-SA for ballot invitation and MEC review	Complete
Q2-Q4 2019	IEEE-SA balloting and ballot resolution of P1547.1 (iterative)	Complete
Q1 2020	UL 1741 begin revision draft to incorporate new 1547.1 and 1547	In progress
Q1 2020	**Milestone:** IEEE-SA ballot approval of P1547.1	Complete
Q1 2020	IEEE RevCom review of P1547.1 In parallel: Finalize UL 1741 ballot document to incorporate new 1547.1.	In progress
Q1/Q2 2020	**Milestone:** 1547.1 finalization and publication	
Q1/Q2 2020	UL Standards Technical Panel review and ballot updated UL 1741	
Q2/Q3 2020	**Milestone:** UL 1741 update published	
Q3 2020 – Q4 2021	Inverter manufacturers update and recertify products to UL 1741	
Q4 2020 – Q4 2021	UL 1741 / 1547-2018 compliant inverters expected to be available on market. (Date expected to vary by manufacturer within this window.)	

PPL Electric Exhibit WR-2R

Resolution Recommending State Commissions Act to Adopt and Implement Distributed Energy Resource Standard IEEE 1547-2018

Whereas State commissions have statutory responsibility for regulating utilities that provide energy services;

Whereas State commissions have a statutory obligation to ensure that the electric utilities they regulate provide safe and reliable service at just and reasonable rates;

Whereas many States are experiencing the installation and interconnection of distributed energy resources ("DERs"), as sources of electric power that are connected to, operate in parallel with, and are capable of exporting power to local distribution systems, including, but not limited to, distributed solar photovoltaic generation and distributed energy storage;

Whereas many States recognize that DER, if interconnected and operated in a safe and reliable manner with uniform standards across multiple jurisdictions, can offer economic, reliability, resilience, and environmental benefits to consumers, communities and utilities;

Whereas all States benefit from timely adoption of rigorous, clear, up-to-date standards for safe and reliable interconnection, integration and parallel operation of DERs;

Whereas in April 2018, the Institute for Electrical and Electronics Engineers ("IEEE") published a significantly updated *IEEE Standard 1547TM --2018 for Interconnection and Interoperability of DERs and Associated Electric Power Systems Interfaces* ("IEEE 1547-2018"), which is a voluntary, nationally applicable standard that will transform how DERs interact with and function on the electric distribution system;

Whereas IEEE 1547-2018 is technology neutral and specifies the performance and functional technical capability requirements needed to ensure technically sound interconnections, as well as a number of necessary improvements for distribution and bulk power system reliability;

Whereas IEEE 1547-2018 requires DER to be capable of performing specific grid support functions related to voltage, frequency, communications, and controls to ensure that increasing levels of DERs are reliable at both the distribution and bulk power system levels, and can be visible to grid operators;

Whereas DER equipment compliant with IEEE 1547-2018 is anticipated to be available in the 2021 timeframe; reliable deployment of this equipment requires consideration and coordination by State regulators and utilities as outlined in the standard;

Whereas IEEE 1547-2018 highlights responsibilities, including determination of performance categories, of State regulators and other authorities governing interconnection requirements;

Whereas delaying implementation of IEEE 1547-2018 could result in new DERs being connected to the grid using legacy technical requirements and standards that could prevail for the duration of the DER's lifetime;

Whereas significant logistical and legal barriers exist to modifying DER interconnection requirements post-installation, such that it is preferable to apply the desired DER configuration at the time of initial DER installation;

Whereas the North American Electric Reliability Corporation ("NERC"), in the draft Reliability Guideline, "Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018" encourages State regulators to "support early implementation of IEEE 1547-2018 and begin engaging with necessary stakeholders;"

Whereas adoption and implementation of IEEE 1547-2018 requires action by State regulators and utilities to integrate the standard into interconnection tariffs, such as addressing issues related to technology, location, settings of utility-owned protective elements, among other factors;

Whereas successful State implementation of the updated IEEE 1547-2018 will benefit from stakeholder engagement, including electric distribution system operators, DER customers and developers, and bulk power system operators, and identifying and engaging such subject matter experts may take significant lead-time;

Whereas NARUC, IEEE, Electric Power Research Institute, National Renewable Energy Laboratory, Regulatory Assistance Project, Interstate Renewable Energy Council, NERC, National Rural Electric Cooperative Association and others have compiled excellent resources to support State commissions on IEEE 1547-2018 implementation based on evidence and research;

Whereas IEEE and nationally recognized testing laboratories are working on testing procedures (IEEE 1547.1) and certification (UL 1741) based on IEEE 1547-2018 with the anticipation of widespread availability of certified equipment in 2021; *now, therefore be it*

Resolved that the Board of Directors of the National Association of Regulatory Utility Commissioners, convened at its 2020 Winter Policy Summit in Washington, DC, recommend State commissions, consistent with the practices and procedures of that State, convene proceedings that engage stakeholders soon; utilize existing research and experience and make evidence-based decisions to adopt the current IEEE 1547; and align implementation of the standard with the availability of certified equipment.

Sponsored by the Committee on Electricity
Adopted by the Board of Directors, on February 12, 2020

PPL Electric Exhibit WR-3R

December 2019

U.S. SOLAR MARKET INSIGHT

Executive summary

Q4 2019

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ABOUT THE REPORT

U.S. Solar Market Insight® is a quarterly publication of Wood Mackenzie Power & Renewables, Inc. d/b/a Greentech Media and the Solar Energy Industries Association (SEIA)®. Each quarter, we collect granular data on the U.S. solar market from nearly 200 utilities, state agencies, installers and manufacturers. This data provides the backbone of this U.S. Solar Market Insight® report, in which we identify and analyze trends in U.S. solar demand, manufacturing and pricing by state and market segment. We also use this analysis to look forward and forecast demand over the next five years. All forecasts are from Wood Mackenzie, Limited; SEIA does not predict future pricing, bid terms, costs, deployment or supply.

- References, data, charts and analysis from this executive summary should be attributed to "Wood Mackenzie/SEIA U.S. Solar Market Insight®."
- Media inquiries should be directed to Wood Mackenzie's PR team (WoodmacPR@woodmac.com) and Morgan Lyons (mlyons@seia.org) at SEIA.
- All figures are sourced from Wood Mackenzie. For more detail on methodology and sources, visit www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/.
- Wood Mackenzie Power & Renewables partners with Clean Power Research to acquire project-level datasets from participating utilities that use the PowerClerk product platform. (For more information on Clean Power Research's product offerings, visit https://www.cleanpower.com/.)

Our coverage in the U.S. Solar Market Insight reports includes 44 individual states and Washington, D.C. However, the national totals reported include all 50 states, Washington, D.C. and Puerto Rico.

Detailed data and forecasts for 44 states and Washington, D.C. are contained within the full version of this report, available at www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/.

Note on U.S. Solar Market Insight report title: The report title is based on the quarter in which the report is released, as opposed to the most recent quarter of installation figures. The exception is our year in review publication, which covers the preceding year's installation figures but is published in the first quarter of the year.

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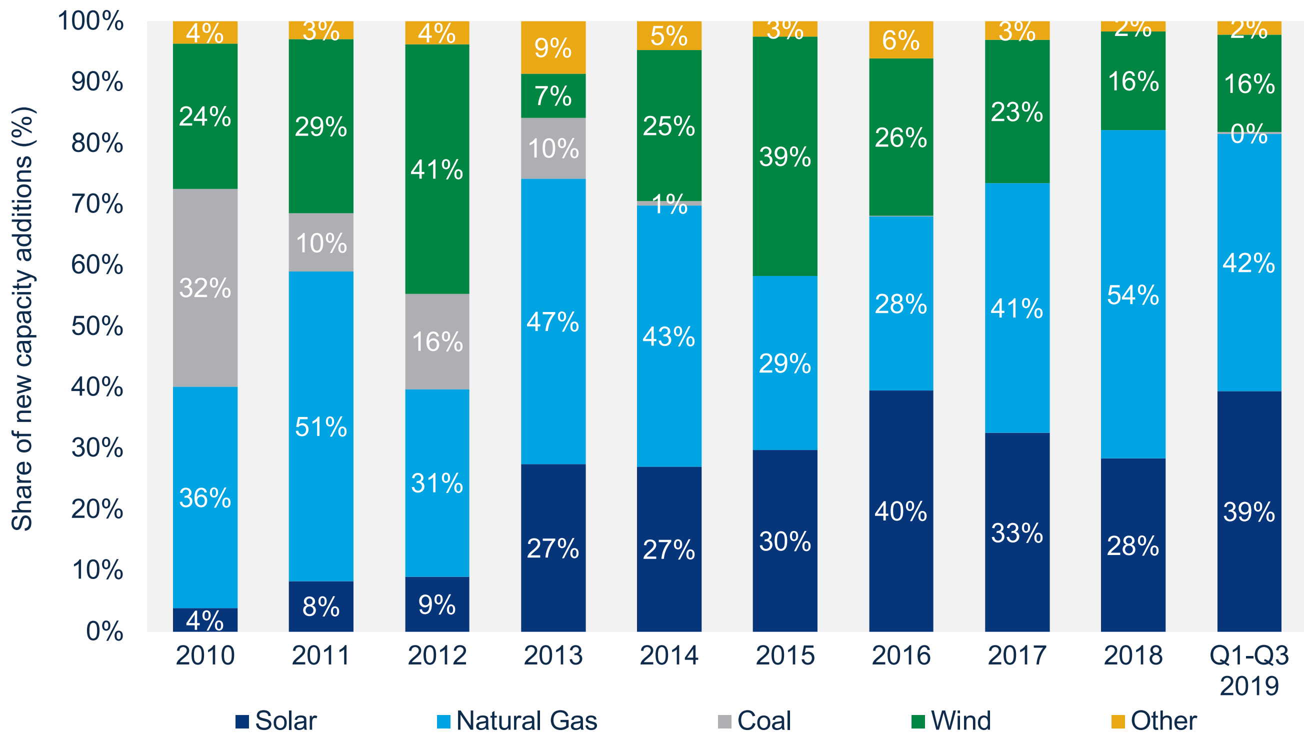
1. KEY FIGURES

- In Q3 2019, the U.S. solar market installed 2.6 GW_{dc} of solar PV, representing a 45% increase from Q3 2018 and a 25% increase from Q2 2019.
- The U.S. saw record-setting residential solar capacity added with more than 700 MW installed.
- A total of 21.3 GW_{dc} of new utility PV projects were announced from Q1 to the end of Q3, bringing the contracted utility PV pipeline to a record high of 45.5 GW_{dc}.
- Non-residential PV saw 445 MW_{dc} installed as policy shifts in states including California, Massachusetts and Minnesota continue to impact growth.
- Wood Mackenzie forecasts 23% year-over-year growth in 2019, with 13 GW_{dc} of installations expected. In total, more than 9 GW were added to the five-year forecast since last quarter to account for new utility-scale procurement.
- Total installed U.S. PV capacity will more than double over the next five years, with annual installations reaching 20.1 GW_{dc} in 2021 prior to the expiration of the federal Investment Tax Credit for residential systems and a drop in the commercial credit to 10% (under the current version of the law).

2. INTRODUCTION

In Q3 2019, the U.S. solar market installed 2.6 gigawatts (GW_{dc}) of solar photovoltaic (PV) capacity, a 45% increase year-over-year. The residential solar rebound continues to gain steam with the market growing 10% quarter-over-quarter and 18% year-over-year – the second consecutive quarter in which the residential segment grew across both metrics. Conversely, non-residential PV was flat on a quarterly basis and continues to see pipelines diminish due to policy transitions and persistent interconnection issues in key commercial markets. More than 1.4 GW_{dc} of utility-scale installations came online this quarter with new project procurement growing the contracted pipeline to 45.5 GW_{dc}. Across all market segments, solar PV accounted for **39%** of all new electricity-generating capacity additions in 2019 through Q3.

Figure 2.1 New U.S. electricity-generating capacity additions, 2010-Q3 2019



Source: Wood Mackenzie Power & Renewables, FERC (for category "All other technologies")

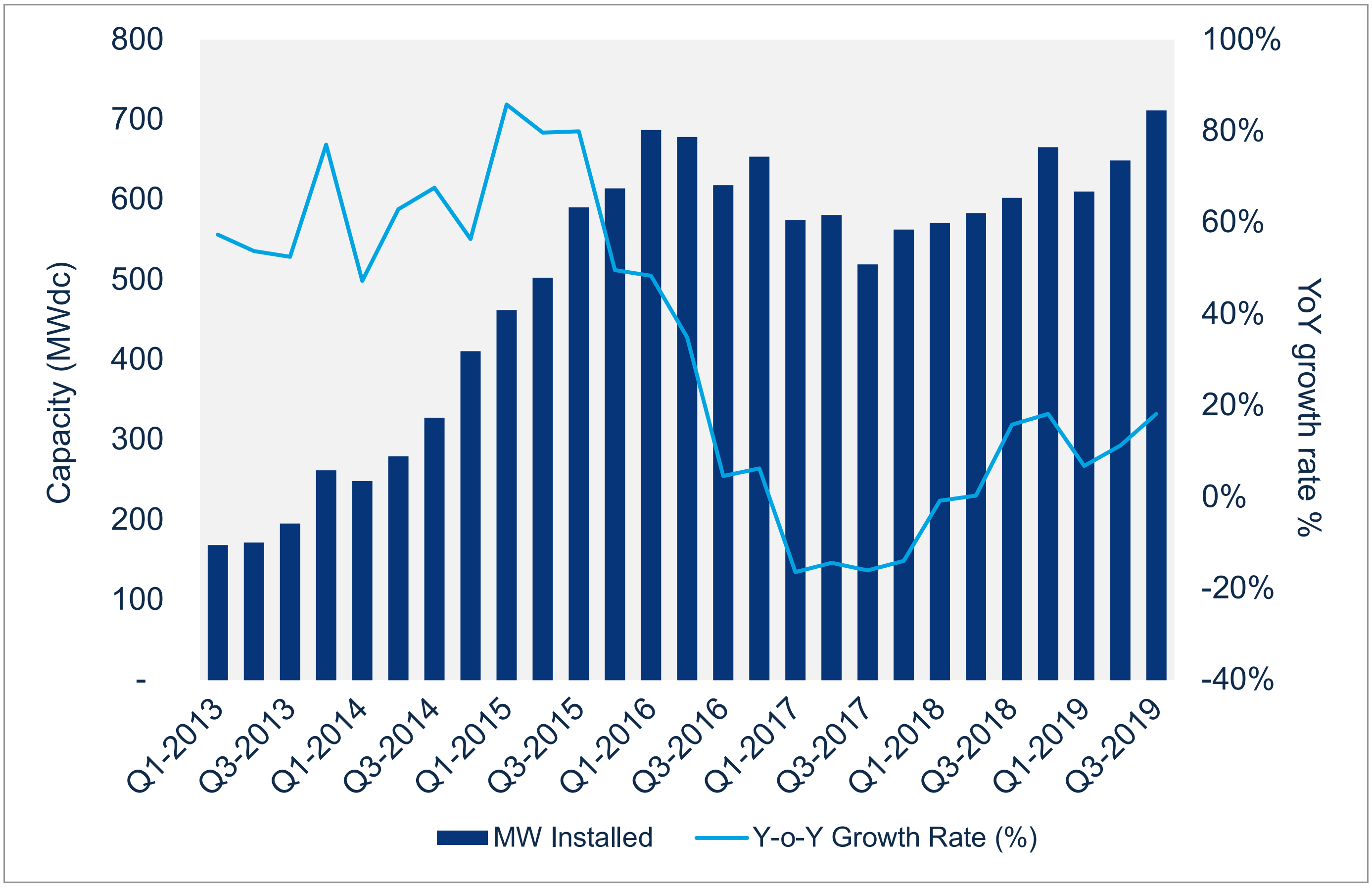
Don't call it a comeback: California drives the largest quarter ever for rooftop PV

After years of steady double-digit-percentage growth over the first half of this decade, the U.S. residential sector experienced growing pains from 2016-2017 as national installers pulled back across critical geographies in California and the Northeast. But while the market has regained steam since, the sector had yet to surpass its quarterly installed capacity peak of 687 MW_{dc} set in Q1 2016. That all changed in Q3 2019 when the market installed more than 700 MW_{dc} of residential capacity.

That said, there are layers of nuance in both where this growth is coming from and what is driving it. From a geographic perspective, California continues to be the largest residential market, installing nearly 300 MW in Q3 2019 and thus breaking its quarterly record. But as prices have come down, growth has spread to a broader swath of states. Outside of California, 14 additional states had record quarters, ranging from top 10 markets like Florida and Texas to smaller markets in Idaho and New Mexico. These emerging markets have begun to supplement steady installation volumes in the Northeast, a region that historically has accounted for nearly as much residential solar as California.

While California has always led the country in solar deployment, the drivers behind that growth have shifted to focus on two tracks. The first is new-build home solar demand beginning to ramp up in anticipation of the state mandate that takes effect in 2020. The second – and more unexpected – driver is increased consumer interest in solar and solar-plus-storage options in response to dissatisfaction with California utilities. This disaffection has a long history but most recently stems from Public Safety Power Shutoffs (PSPS) which have left hundreds of thousands of utility customers without electricity, often for days at a time. These developments have combined to renew a latent demand in solar and resiliency options in California, while national coverage of the issues has increased interest in solar paired with storage outside the state.

Figure 2.2 Residential quarterly installation volumes, Q1 2013-Q3 2019



Source: Wood Mackenzie Power & Renewables

Non-residential PV enters a second consecutive year of annual decline

Unlike in the residential market, a handful of state-specific regulatory cliffs and policy reforms that took effect in 2018 continued to impact non-residential installations through Q3 2019. Major policy reforms continued to hamper development in the core non-residential markets of California, Massachusetts and Minnesota. In the case of California, installations were flat quarter-over-quarter but down year-over-year, suggesting that installation declines stemming from the transition to new time-of-use rates are real but abating. In Massachusetts, non-residential deployment numbers continue to be impacted by interconnection delays and the ongoing National Grid cluster study, despite a pipeline of mechanically complete projects that are sitting idle. Accordingly, the Bay State had its lowest quarter of non-residential PV interconnected since 2011.

Positive policy developments in New York, Maryland, Maine and New Jersey over the first half of 2019 will boost the non-residential space from 2020-2022 before it declines in 2023 in response to the step-down of the solar Investment Tax Credit under current federal law.

New utility procurement breaks records while 100% renewables targets and offsite corporate demand boost long-term outlook

Utility PV maintained the largest share of installed capacity in the U.S. solar market this quarter. A total of 1.4 GW_{dc} of utility PV capacity came online in Q3 2019, representing 55% of quarterly capacity additions. Wood Mackenzie projects an additional 4.6 GW_{dc} of utility PV capacity additions in Q4, bringing the total for 2019 to more than 8 GW_{dc}.

A total of 10.4 GW_{dc} of projects are currently under construction, a record high for U.S. utility-scale solar. Additionally, 8.1 GW_{dc} of new projects were announced in Q3 2019. With 21.3 GW_{dc} of new projects announced through the end of Q3 2019, the contracted pipeline has now reached 45.5 GW_{dc}**, the highest it has ever been in the history of U.S. utility-scale solar.** The massive growth of new projects continues to be spurred by utilities and developers looking to safe-harbor enough equipment for as much capacity as possible under the 30% ITC. Notably, 5.4 GW_{dc} of projects have been announced in Texas. While most projects have utility or corporate offtakers, a growing portion of them are being built as merchant projects to sell power directly into the ERCOT market.

Overall demand for utility PV will remain robust through 2024 even after the current surge in procurement subsides. Utilities such as Tennessee Valley Authority, PacifiCorp, Duke Energy and Idaho Power have all released updated integrated resource plans that outline increasingly ambitious utility-scale solar procurement targets for dates both before and after the ITC step-down. Additionally, the number of new and repeat corporate offtakers continues to rise, with 4.8 GW_{dc} of new offsite C&I projects announced so far in 2019.

Voluntary procurement of utility PV based on cost-competitiveness continues to be the primary driver of projects announced in 2019, accounting for 51% of the total. This procurement has been driven by the low cost of utility PV, with recently signed PPA prices ranging from $18 to $35/MWh.

Figure 1.3 State solar PV installation rankings, Q3 2019

	Rank			Installations (MW_{dc})		
State	**2017**	**2018**	**Q1-Q3 2019**	**2017**	**2018**	**Q1-Q3 2019**
California	1	1	**1**	2,599	3,240	**1,911**
Florida	3	4	**2**	758	866	**1,109**
Texas	4	2	**3**	713	994	**498**
South Carolina	8	12	**4**			
North Carolina	2	3	**5**			
Hawaii	17	17	**6**			
New Jersey	11	7	**7**			
New York	12	6	**8**			
Arizona	7	9	**9**			
Georgia	22	35	**10**			
Minnesota	6	8	**11**			
Nevada	9	5	**12**			
Maryland	13	13	**13**			
Utah	19	26	**14**			
Colorado	20	11	**15**			
Rhode Island	30	23	**16**			
Massachusetts	5	10	**17**			
Connecticut	21	15	**18**			
Virginia	10	14	**19**			
Tennessee	25	32	**20**			
Illinois	41	33	**21**			
Pennsylvania	26	25	**22**			
Missouri	37	31	**23**			
Indiana	24	27	**24**			
Ohio	29	29	**25**			
New Mexico	27	20	**26**			
Vermont	31	21	**27**			
Wisconsin	33	38	**28**			

Underlying data available in the full report

	Rank			Installations (MW_{dc})		
State	2017	2018	Q1-Q3 2019	2017	2018	Q1-Q3 2019
Washington	34	24	29	Underlying data available in the full report		
Michigan	23	30	30			
Iowa	35	34	31			
Arkansas	43	18	32			
Oregon	14	16	33			
Idaho	16	22	34			
New Hampshire	39	39	35			
Maine	-	-	36			
Washington, D.C.	40	36	37			
Mississippi	15	41	38			
Louisiana	42	37	39			
Delaware	38	40	40			
Montana	28	44	41			
Kentucky	36	43	42			
Oklahoma	32	42	43			
Wyoming	44	19	44			
Alabama	18	28	45			

Source: Wood Mackenzie Power & Renewables

3. MARKET SEGMENT OUTLOOKS

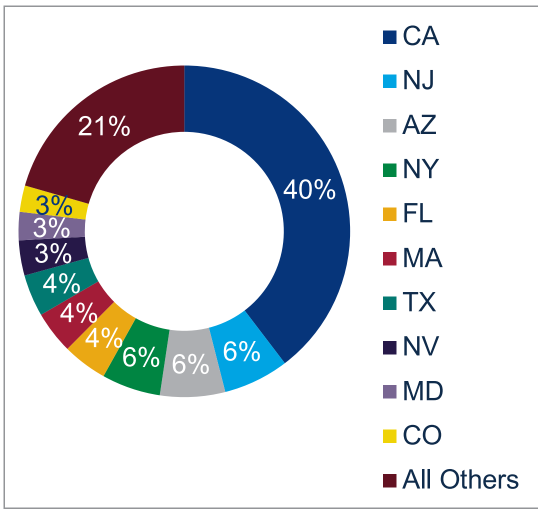
3.1. Residential PV

Key figures

- 712 MW_{dc} installed in Q3 2019
- Up 18% from Q3 2018
- Up 10% from Q2 2019

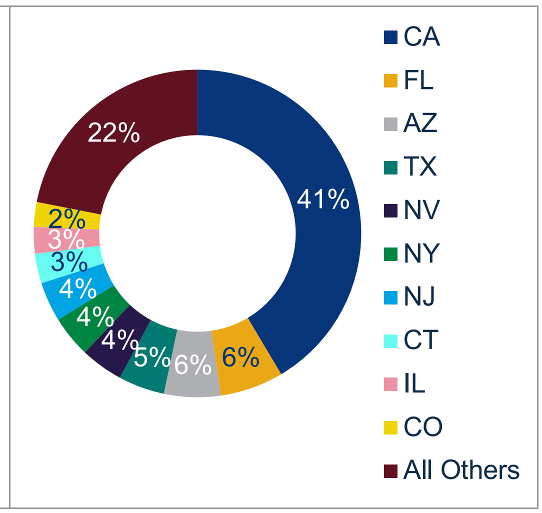
Q3 2019 was significant for residential solar for several reasons. Beyond being the largest quarter in history in terms of installations, Q3 also saw a shake-up at the top of the residential solar rankings. This was the first quarter in which a Northeast state – historically a regional leader in residential PV – did not rank among the top five state markets. Instead, the top five state markets are a mixture of mature and emerging markets, with solid installation totals coming from legacy markets California and Arizona but also from newcomers Florida (No. 2), Texas (No. 4), and Nevada (No. 5).

Figure 3.1 Top 10 states, Q3 2018



Source: Wood Mackenzie Power & Renewables

Figure 3.2 Top 10 states, Q3 2019



Source: Wood Mackenzie Power & Renewables

But while these markets are home to increasingly attractive project economics, geographic diversification has been made possible in part by a slowdown in Northeast markets. Here, higher levels of saturation and the resulting steep customer-acquisition costs have slowed installation volumes since peak installation years, as the market grows past early-adopter consumers. These higher soft costs remain a long-term risk to the national market over the next few years, especially if the solar Investment Tax Credit steps down as scheduled under current law and so long as cost continues to be the foremost criterion in the choice to adopt solar.

Based on what we've seen in California, going forward, residential solar adoption may be driven by other factors such as resiliency and concerns about climate change. In California, the combination of new-build home solar adoption (beginning to gain steam in 2019, but legally required for most single-family homes starting in 2020) and increasing disaffection with utilities due to public safety power shutoffs (PSPS) is beginning to drive solar installations, increasingly paired with storage. While these drivers are currently specific to California, national press coverage of PSPS and wildfires in the state have the potential to resonate with homeowners across the country, creating demand for solar-based resiliency options outside the Golden State.

From 2019-2021, residential growth will range from 8% to 18% due to both emerging markets with strong resource fundamentals like Florida and Texas and markets where recent policy developments have increased our near-term forecasts. Maryland's recent renewable portfolio standard increase, the removal of South Carolina's net metering cap, and new incentive programs such as Illinois' Adjustable Block Program will provide upside and growth to our residential forecasts over the next few years.

In the long term, the ITC step-down is expected to pull in demand in both legacy and emerging markets before expiring in 2022 for customer-owned systems. Modest growth resumes in 2023 and continues into 2024 based on economic fundamentals as the market adjusts to less attractive post-ITC market conditions. Long-term growth in a post-ITC world will be contingent on geographic diversification outside of legacy state markets (with markets like Pennsylvania and Colorado beginning to take off), as well as technological and business-model innovation to improve product offerings in the solar-plus-storage space.

3.2. Non-residential PV

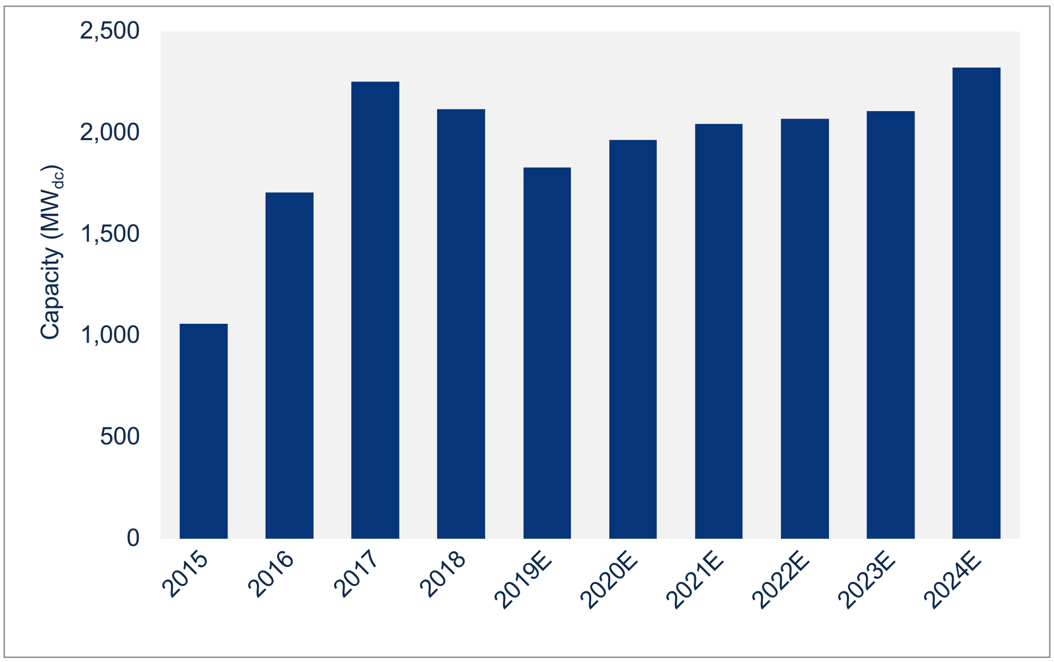
- 445 MW_{dc} installed in Q3 2019
- Flat over Q2 2019
- Down 6% from Q3 2018

Non-residential installations have essentially remained flat since Q1 2019 as California and Massachusetts continue to see declining volumes due to state-level policy reforms and interconnection delays that limit development opportunities. Overall, the non-residential PV market is on track for a down year as the segment acclimates to a reduced incentive environment across major state markets. However, this will be incrementally offset starting in 2020 as the next wave of states with robust community solar mandates – New York, Maryland, Illinois and New Jersey – experience growth.

Recent policy developments in the Northeast will ultimately spur growth in our long-term outlook. New Jersey has proposed revising its transition incentive program, slightly raising incentive values for community solar projects. Significant revisions to the Value of Distributed Energy Resources (VDER) docket in New York have bolstered our long-term forecasts for both commercial and community solar. Meanwhile, Maryland and Maine both passed more aggressive RPS policies, which are expected to boost lagging REC markets. Maine went even further to create a commercial solar tariff and community solar program.

Increasing solar-plus-storage viability will also begin to have an impact on non-residential demand as policymakers and business leaders increasingly consider energy storage in their decisions. New York's recent development of the Bridge Incentive increases our long-term solar-plus-storage forecasts with further potential upside. By 2023, roughly 30% of total non-residential PV capacity will come from community solar, and 20% of all non-residential capacity is expected to have storage attached.

Figure 3.3 Non-residential installations and forecast, 2015-2024E



Source: Wood Mackenzie Power & Renewables

3.3. Utility PV

- 1,410 MW_{dc} installed in Q3 2019
- Utility PV pipeline currently totals 45.5 GW_{dc}

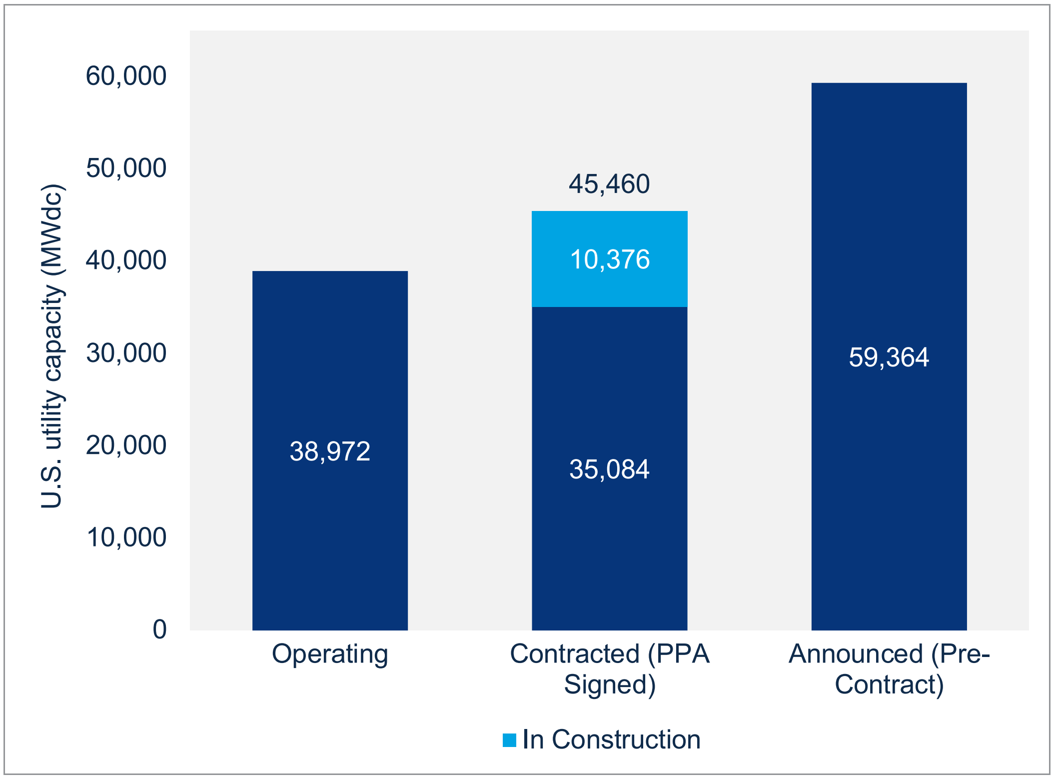
The U.S. utility solar forecast for 2019-2024 has grown by 9.2 GW_{dc} since last quarter thanks to unprecedented levels of procurement driven by increasing cost-competitiveness with other sources. New project announcements are exceeding project completions as developers and utilities look to safe-harbor as much capacity as possible before the ITC steps down. We also continue to see a growing volume of utility-scale solar in long-term resource plans and requests for proposals.

Since last quarter, the 2019 forecast has increased slightly to 8.4 GW_{dc}. The forecasts for 2020 and 2021 have increased by 1.6 and 2.5 GW_{dc}, respectively. The driver for the near-term increase in the forecast has been our growing confidence in 2019 projects meeting their commercial operation dates (CODs) along with the rise in project announcements. There were 8.1 GW_{dc} of new projects announced in Q3 2019, including 1.3 GW_{dc} specifically targeting 2020 CODs and 3.3 GW_{dc} targeting 2021 CODs.

Our utility PV forecast has increased by 5.0 GW_{dc} for 2022-2024. While a portion of this can be attributed to 3.2 GW_{dc} of newly procured projects with 2022-2023 target CODs, we expect that utility demand for solar will continue to increase. The cost-competitiveness of utility PV has made it the primary resource for utilities seeking additional energy capacity, as well as those looking to meet more stringent RPS targets. This is in part due to utility PV becoming increasingly cost-competitive with wind, gas and other electricity generation resources. As the wind-focused federal Production Tax Credit steps down, solar begins to fall below the cost of wind on a levelized cost of energy basis in many traditional wind states. In states such as Illinois, Iowa, Kansas, Michigan and the Dakotas, solar competes with wind on a cost basis by the mid-2020s, while also providing a complementary production profile.

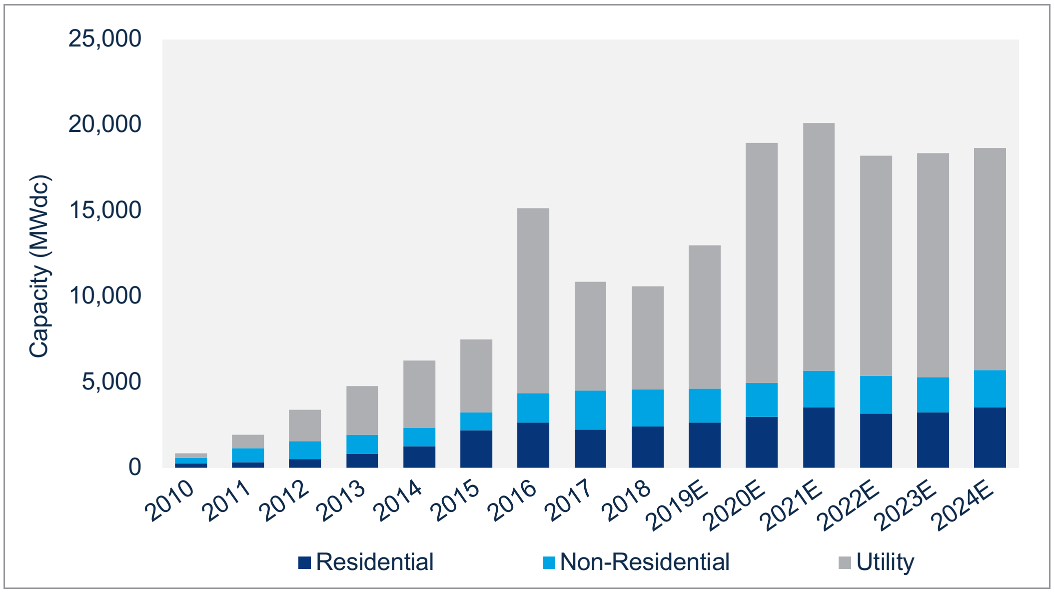
The low cost of utility PV has also increased demand from corporate offtakers: 4.8 GW_{dc} of utility-scale solar projects with corporate offtakers have been announced thus far in 2019. Currently, 3.9 GW_{dc} of the projects expected to come online in 2020 have a corporate offtaker, representing 28% of the 2020 forecast. While a short-term increase in demand could be inflated by corporate offtakers securing low-priced power-purchase agreements before the ITC steps down, we believe offsite corporate demand will continue to grow across the U.S. as more corporate and industrial offtakers pledge to become carbon-neutral or powered by 100% renewables. Consequently, Wood Mackenzie expects that corporate demand will drive more than 20% of utility solar development from 2019-2024.

Figure 2.4 U.S. utility PV pipeline



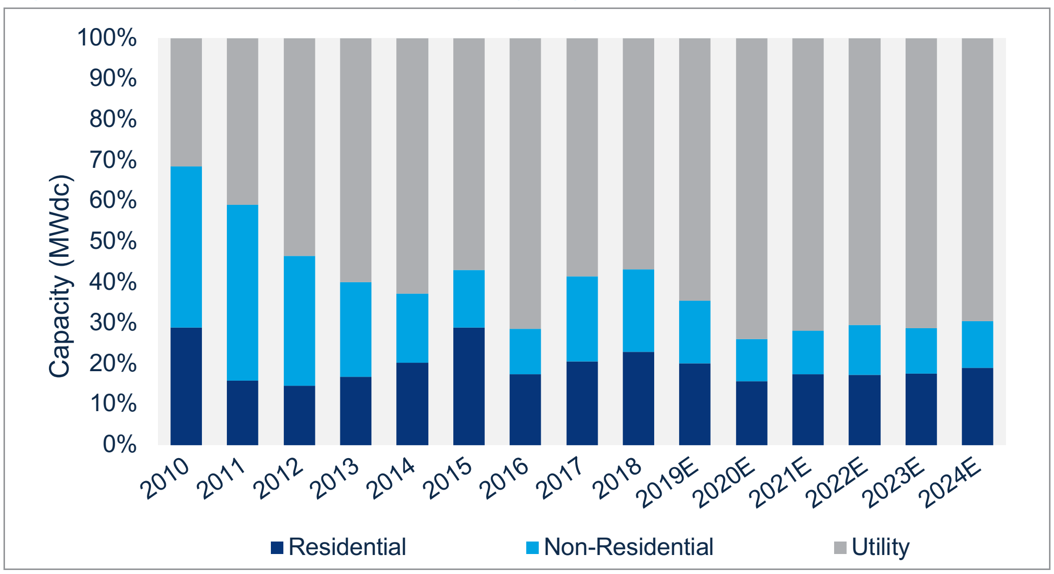
Source: Wood Mackenzie Power & Renewables

Figure 2.5 U.S. PV installation forecast, 2010-2024E



Source: Wood Mackenzie Power & Renewables

Figure 2.6 U.S. PV installation forecast by segment, 2010-2024E

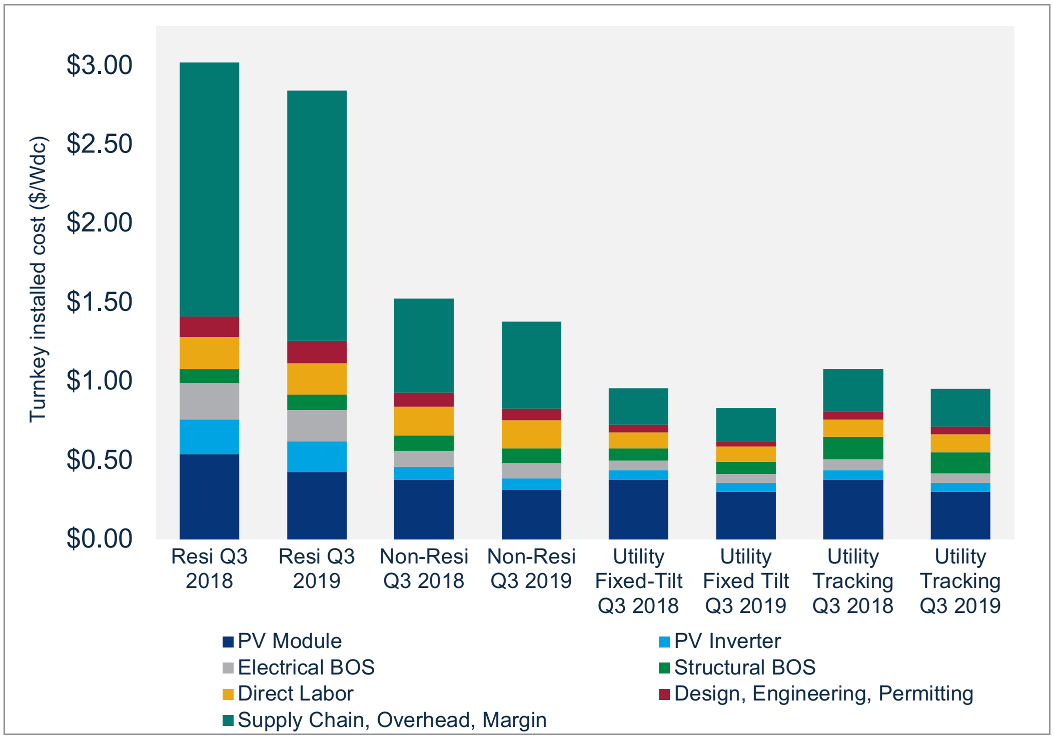


Source: Wood Mackenzie Power & Renewables

4. NATIONAL SOLAR PV SYSTEM PRICING

We employ a bottom-up modeling methodology to capture, track and report national average PV system pricing for the major market segments. Our bottom-up methodology is based on tracked wholesale pricing of major solar components and data collected from multiple interviews with industry stakeholders.

Figure 3.1 Modeled U.S. national average system costs by market segment, Q3 2018 and Q3 2019



Source: Wood Mackenzie Power & Renewables

Note: Detailed information about national system prices by market segment and component is available in the full report.

In Q3 2019, system pricing fell across all market segments. System pricing fell quarter-over-quarter by 1.0%, 5.0%, 7.5% and 5.6% in the residential, non-residential, utility fixed-tilt and utility single-axis tracking markets, respectively. Prices across all market segments are now at an all-time low: $2.84/W$_{dc}$, $1.38/W$_{dc}$, $0.83/W$_{dc}$ and $0.95/W$_{dc}$ for residential, non-residential, utility fixed-tilt and utility single-axis tracking systems, respectively. Year-over-year system pricing fell by 6.0%, 9.4%, 13.1% and 11.6% in the residential, non-residential, utility fixed-tilt and utility single-axis tracking markets, respectively.

5. COMPONENT PRICING

Starting in Q1 2019, the *U.S. Solar Market Insight* report series expanded its coverage to include pricing information on mono wafer, mono cells and mono modules, in addition to their multi counterparts. In Q3 2019, global spot market pricing for all major components dropped slightly from Q2. Polysilicon prices decreased by more than 4% in Q3, creating a trickle-down price reduction along the entire supply chain. Mono cell global spot prices continued to fall for the second quarter in a row, further confirming that the market has excess supply. Compared to Q2, mono module prices were 2 cents lower in Q3, thanks to the continuous expansion of mono cell and module production capacities around the globe.

In the U.S., multi-silicon module prices declined slightly to $0.31/W in Q3 2019 from $0.32/W in Q2 2019. (Note: U.S. multi-silicon module prices have been lowered retroactively due to an update in our methodology for module pricing.)

For the second quarter in a row, mono PERC module prices increased. In Q3, the U.S. average utility-scale mono PERC module price was around $0.44/W, 10% higher than at the beginning of the year. It reflects the strong demand for the product as well as tight module supply to the U.S. market due to tariffs.

Figure 4.1 Polysilicon, wafer, cell and module prices, Q3 2018-Q3 2019

	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Q3 2019
Polysilicon ($/kg) *	$11.7	$ 9.9	$ 9.3	$ 8.9	$ 8.5
Multi wafer ($/W) *	$ 0.07	$ 0.06	$ 0.06	$ 0.06	$ 0.05
Mono wafer ($/W) *	$ 0.09	$ 0.08	$ 0.08	$ 0.09	$ 0.08
Multi cell ($/W) *	$ 0.13	$ 0.11	$ 0.11	$ 0.12	$ 0.11
Mono cell ($/W) *	$ 0.14	$ 0.13	$ 0.14	$ 0.12	$ 0.11
Multi module ($/W) *	$ 0.26	$ 0.23	$ 0.23	$ 0.23	$ 0.22
Mono module ($/W) *	$ 0.30	$ 0.27	$ 0.28	$ 0.28	$ 0.26
U.S. multi module ($/W)	$ 0.34	$ 0.34	$ 0.33	$0.32	$0.31
U.S. mono PERC module ($/W)	$ 0.44	$ 0.41	$ 0.40	$0.43	$0.44

Source: Wood Mackenzie Power & Renewables

**Global spot prices*

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VERIFICATION

I, WANDA REDER, being the President and CEO of Grid-X Partners, LLC, hereby state that the facts above set forth are true and correct to the best of my knowledge, information and belief and that I expect PPL Electric Utilities Corporation to be able to prove the same at a hearing held in this matter. I understand that the statements herein are made subject to the penalties of 18 Pa.C.S. § 4904 relating to unsworn falsification to authorities.

Date: 3/4/2020

Wanda Reder