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

DIRECT TESTIMONY OF SALIM SALET

PPL Electric Statement No. 1

December 11, 2019

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Salim Salet, and my business address is 2 North Ninth Street, Allentown, PA 18101.

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

A. I am employed by PPL Electric Utilities Corporation ("PPL Electric" or the "Company") as Director – Operations.

Q. WOULD YOU PLEASE DESCRIBE PPL ELECTRIC?

A. PPL Electric is a corporation organized and existing under the laws of the Commonwealth of Pennsylvania. PPL Electric is a wholly-owned direct subsidiary of PPL Corporation. I have been advised by counsel that PPL Electric is a "public utility," an "electric distribution company" and a "default service provider" as defined in Sections 102 and 2803 of the Public Utility Code, 66 Pa. C.S. §§ 102, 2803.

Q. WHAT ARE YOUR DUTIES AS DIRECTOR – OPERATIONS?

A. I am primarily responsible for: (1) 24/7 control and operation of the PPL EU electrical distribution system, (2) executing business plans for operating and managing PPL Electric's distribution system; and (3) identifying best industry practices and benchmarking for managing and controlling the configuration of the Company's distribution system as well as driving improvements in reliability.

Q. WHAT IS YOUR EDUCATIONAL BACKGROUND?

A. I received a B.S. degree in Electrical Engineering from Pennsylvania State University in May 2006, and master's degree in business administration from the University of Saint Leo in December 2017. I am also a licensed Professional Engineer in the state of Pennsylvania since October 2010.

Q. PLEASE DESCRIBE YOUR PROFESSIONAL EXPERIENCE.

A. I have been employed by PPL Electric since I graduated from Penn State in May of 2006. During my 13-year career in the energy industry, I have held multiple positions and gained valuable experience in various functions of the industry. Below is the list of these positions:

- May 2006 – December 2009 – Substations Engineer – I was responsible for developing scope, schedule, cost estimates, physical electrical design, and relay and control protections design for various grid upgrade and enhancement projects on the distribution and transmission grid.
- December 2009 – April 2012 – Support Engineer – I was responsible for designing and programming control systems for PPL Electric's smart grid automation system.
- April 2012 – June 2014 – Supervising Engineer – I led a group of engineers and technicians responsible for designing and maintaining PPL Electric's distribution and transmission substation control systems.
- June 2014 – July 2015 and May 2016 – April 2017 – Manager, Relay Engineering – I led a group of 45 engineers and technicians on multiple distribution and

transmission grid upgrade projects. The projects included upgrades to PPL Electric's distribution and transmission management system.

- July 2015 – May 2016 – Manager, Distribution Engineering – I led a group of 30 engineers and technicians on multiple distribution design, standards, and protection projects. The group was responsible for developing and maintaining distribution standards, designing large distribution system upgrade projects, designing underground systems upgrades, and designing protection schemes for all distribution projects.
- April 2017 – March 2019 – Director, Distribution Engineering – I led a group of 125 engineers and technicians with the responsibility to develop short and long-term strategy for PPL Electric's distribution system. Some of the group's responsibilities included: (1) prioritizing investments in the distribution grid to overcome current and future challenges with a total annual budget of approximately $300 million; and (2) leveraging new technologies to improve the operation and quality of the services provided by PPL Electric.
- March 2019 – Present – I have been in my current role as Director of Operations for PPL Electric's distribution organization.

Q. HAVE YOU PREVIOUSLY TESTIFIED AS A WITNESS BEFORE THE PENNSYLVANIA PUBLIC UTILITY COMMISSION ("COMMISSION")?

A. No.

Q. WOULD YOU PLEASE DESCRIBE THE SUBJECT MATTER OF YOUR TESTIMONY?

A. My testimony will: (1) provide an overview of other witnesses' direct testimony; (2) provide an overview of the Company's proposal to implement its Distributed Energy Resources ("DER") Management Plan, which will govern the interconnection and operation of new DERs deployed in the Company's service territory; (3) describe the Company's requested tariff modifications; (4) outline the waivers of regulations that the Company is requesting; and (5) address technical questions that have been raised about the Company's proposal.

Q. ARE YOU SPONSORING ANY EXHIBITS WITH YOUR TESTIMONY?

A. Yes, I am sponsoring the following exhibit:

- PPL Electric Exhibit SS-1 – PPL Electric's *pro forma* tariff supplement establishing the new PPL Electric "Rule 12 – Distributed Energy Resources Interconnection Service" ("DERIS").

A. OVERVIEW OF OTHER WITNESSES' DIRECT TESTIMONY

Q. WOULD YOU PLEASE PROVIDE AN OVERVIEW OF THE OTHER WITNESSES WHO ARE SUBMITTING DIRECT TESTIMONY ON BEHALF OF PPL ELECTRIC IN THIS PROCEEDING?

A. Below is a list of the other witnesses and the subject matters of their direct testimony:

- PPL Electric Statement No. 2 – Direct Testimony of Wanda Reder – Ms. Reder will describe the implications and effects of DERs, including the experiences of utilities in

other states and countries, and will address questions concerning the applicable Institute of Electrical and Electronics Engineers ("IEEE") and Underwriters Laboratories ("UL") standards under the Company's proposal.

- PPL Electric Statement No. 3 – Direct Testimony of Dr. Karen Miu – Dr. Miu will testify about the need for the Company to implement its DER Management Plan now, including the issues PPL Electric is currently experiencing on its distribution system from the deployment of DERs due to the Company's inability to monitor and manage those systems. She also will explain why the Company's proposal is best addressed in a utility-specific proceeding, rather than a statewide proceeding.
- PPL Electric Statement No. 4 – Direct Testimony of Stephen Whitley – Mr. Whitley will describe the impact of DERs and other "behind the meter resources," including issues that have been experienced in other states due to electric utilities' failures to take steps to monitor and manage these technologies. He also will provide additional support for why the Company's proposal is best addressed in a utility-specific proceeding, rather than a statewide proceeding.
- PPL Electric Statement No. 5 – Direct Testimony of Aaron Bayles – Mr. Bayles will address cybersecurity issues related to the Company's proposal and explain the steps PPL Electric will take to protect its customers' data from unauthorized public disclosure under its DER Management Plan.

B. OVERVIEW OF DER MANAGEMENT PLAN

Q. WOULD YOU PLEASE DESCRIBE THE COMPANY'S PROPOSAL IN THIS PROCEEDING TO IMPLEMENT ITS DER MANAGEMENT PLAN?

A. Yes. PPL Electric filed a Petition seeking Commission approval of tariff modifications and waivers of regulations necessary to implement its DER Management Plan.

The Plan would govern the interconnection and operation of new DERs deployed in the Company's service territory. Under the DER Management Plan, PPL Electric would be able to monitor and manage the DERs interconnected with its distribution system. Specifically, through the instant Petition, PPL Electric has requested to proactively implement the 2018 revisions to the Institute of Electrical and Electronics Engineers ("IEEE") Standard 1547, "Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces" ("IEEE Standard 1547" or "IEEE 1547-2018") and the related, forthcoming revisions to Underwriters Laboratories ("UL") Standard 1741, "Inverters, Converters and Controllers for use in Independent Power Systems" ("UL Standard 1741"). Specifically, under the Company's proposal, customers applying to interconnect new DERs with PPL Electric's distribution system will be required to: (1) use Company-approved smart inverters that are compliant with IEEE 1547-2018 and forthcoming UL Standard 1741 (or until that standard is finalized, UL Standard 1741-SA, as described in Ms. Reder's direct testimony (PPL Electric Statement No. 2)); and (2) install devices that enable PPL Electric to monitor and proactively manage DERs.

Q. CAN YOU GENERALLY EXPLAIN WHY THE COMPANY FILED THE PETITION TO IMPLEMENT ITS DER MANAGEMENT PLAN?

Q. The electric transmission and distribution systems in Pennsylvania and the United States are currently undergoing significant changes. In particular, the increasing deployment

and use of DERs, such as solar panels and batteries, are upending the traditional electric grid model of large scale generation located at significant distances from customers. By allowing customers to both consume and produce electricity at what were traditionally points of delivery, DERs force the electric distribution system to perform in a way for which it was not originally designed and, as a result, place an increasing stress on the grid.

As the deployment of DERs in Pennsylvania continues to increase, my understanding is that the Company still must provide reasonable, safe, reliable, and affordable electric service to all of its customers, including those who have not installed DERs. This can be particularly difficult because electricity cannot be readily stored and generation and load must be balanced at all times. Today, transmission operators, such as PJM Interconnection LLC ("PJM"), manage the transmission grid by maintaining a balance between demand and generation through monitoring and controlling generation assets instantaneously. Traditionally, distribution operators did not have to worry about balancing demand and generation because the distribution grid had very little generation connected to it. However, as the penetration level of DER increases, the classical model of distribution systems is not well-equipped to handle the simultaneous balancing of demand and generation. Therefore, as distribution systems become increasingly similar to transmission, *i.e.*, a mix of demand and generation, the need to balance generation and demand becomes critically important. Such balancing cannot be accomplished without the ability to monitor and manage generation assets on the grid.

Right now, PPL Electric has no ability to readily monitor and manage the DERs interconnected with its distribution system. As more DERs are interconnected with the Company's distribution system, PPL Electric will have to balance demand and generation

simultaneously, as mentioned above, and will increasingly experience issues on its distribution system (like those described by Dr. Karen Miu in her direct testimony (PPL Electric Statement No. 3)) without any way to monitor and manage those resources.

Indeed, solar and other intermittent resources can negatively affect the voltage on the electric distribution system, resulting in delayed interconnection or distribution system reinforcements before additional DERs can be installed. Given PPL Electric's current inability to directly communicate with and manage customer DERs to mitigate resulting power quality issues, such as those detailed later in my testimony, and to leverage grid support functionality, the amount of intermittent generation that can be interconnected must be limited to maintain system stability and reliability. Moreover, in the absence of such ability, the reliability, safety, and efficiency of PPL Electric's service will be placed at increased risk with each new DER that is interconnected with the distribution system. Thus, PPL Electric's Petition is an affirmative step by the Company to address the changing dynamics within the electric utility industry and to better integrate and manage the increased deployment of DERs in its service territory.

Q. HOW MANY DERS ARE CURRENTLY INTERCONNECTED WITH PPL ELECTRIC'S DISTRIBUTION SYSTEM?

A. As of November 30, 2019, there are approximately 9,235 DERs that are interconnected with the Company's distribution system. Of those, approximately 9,072 are solar photovoltaic ("PV") facilities, with the remaining systems primarily consisting of combined heat and power ("CHP"), wind, and biomass.

Q. HOW MANY DER INTERCONNECTION APPLICATIONS DOES PPL ELECTRIC RECEIVE EACH YEAR?

A. On average, PPL Electric receives between 1,000 and 1,500 DER interconnection applications per year, with the overwhelming majority of applications for solar PV systems.

Q. DOES THE COMPANY EXPECT THE NUMBER OF DERS INTERCONNECTED WITH ITS DISTRIBUTION SYSTEM TO INCREASE IN THE FUTURE?

A. Yes, PPL Electric expects an increase in DER interconnection applications in the future based upon historic trends of renewable interconnections throughout Pennsylvania, projected incentives to encourage installations to reduce carbon emissions and slow climate change, and the increasing affordability and efficiency of DER technology. In fact, there are financial incentives, legislative changes, political efforts, and PPL Electric initiatives all contributing to that conclusion.

Q. PLEASE EXPLAIN.

A. Financial incentives from the private sector, state and federal grant programs, and the Federal Investment Tax Credits ("ITC") directly support the development of solar generation. While many state and federal grant programs have ended over the past few years, the ITC is still in effect and utilized by many solar developers and customers. Financial incentives make solar assets less costly and reduce the payback, or break-even

period, directly supporting a customer's ability to install solar assets at their homes and businesses.

Further, in July of 2018, the Pennsylvania Department of Environmental Protection ("DEP") released its draft Pennsylvania's Solar Future Plan ("PSFP") for public review and comment. The PSFP considers various opportunities for Pennsylvania residents and businesses to capitalize on the technical and economic potential of solar electric generation from distributed generation systems and utility-scale solar PV farms. One key proposal of the PSFP is to "[a]ccelerate use of smart inverters to managed [sic] over-voltage concerns on low voltage distribution lines and avoid unnecessarily adding costs on small solar distributed generation projects."[1] Additionally, the PSFP modeled various scenarios that investigated the viability of increasing the state's solar obligation from 0.5% in 2021 to 10% by 2030 – amounting to an estimated 11 gigawatts of new solar generation.[2]

Additionally, I have been advised by counsel that in October of 2017, Governor Wolf signed Act 40[3] into law, which effectively closed Pennsylvania's borders to solar renewable energy credits ("SRECs") generated from solar facilities outside of the Commonwealth. My understanding is that this is expected to support the development of solar facilities within the Commonwealth because electric distribution companies ("EDCs") and electric generation suppliers ("EGSs") must now fulfill their AEPS Act solar obligations from the generation of solar energy within the Commonwealth.

[1] PSFP at 97.
[2] PSFP at xvi.
[3] Act 40 of 2017, H.B. 118, 2017 Pa. Laws 40; *see also Implementation of Act 40 of 2017*, Docket No. M-2017-2631527 (Order entered May 3, 2018), *reconsideration granted in part and denied in part*, Docket No. M-2017-2631527, 2018 Pa. PUC LEXIS 276 (Order entered Aug. 2, 2018).

Moreover, I have been advised by counsel that the passage of Act 58 of 2018 in Pennsylvania,[4] which added Section 1330 of the Public Utility Code,[5] provides utilities the opportunity to utilize alternative rate mechanisms to support the integration of DERs with the distribution system through decoupling mechanisms, demand management, and non-wires alternatives. Relatedly, the Commission's recent Proposed Policy Statement Order on alternative ratemaking methodologies[6] also highlights the potential benefits of decoupling and demand management, which in turn could accelerate DER expansion.

In addition, I have been advised by counsel that on January 8, 2019, Governor Tom Wolf issued an Executive Order, "Commonwealth Leadership in Addressing Climate Change and Promoting Energy Conservation and Sustainable Governance,"[7] which establishes carbon emission reduction targets relating to Commonwealth buildings and operations. My understanding is that one objective of the Order is to procure renewable energy to offset at least 40% of the Commonwealth's annual electricity usage.

The projected increased installation of DER also is supported by the Commission's "*Electric Power Outlook for Pennsylvania 2017-2022*,"[8] which states on page 3 that "a total of 37 GW (nameplate) of solar additions are projected by 2022. Of these, 20 GW (nameplate) are distributed . . . ." The report also states on page 4 that "more robust planning approaches are needed to ensure adequate essential reliability services." This was emphasized by the report's summary of North American Electric

[4] Act 58 of 2018, H.B. 1782, 2018 Pa. Laws 58; *see also Implementation of Act 58 of 2018 Alternative Ratemaking for Utilities*, Docket No. M-2018-3003269 (Order entered Apr. 25, 2019) (setting forth the Commission's interpretation and implementation of Act 58 of 2018).
[5] *See* 66 Pa. C.S. § 1330.
[6] *See Fixed Utility Distribution Rates Policy Statement*, Docket No. M-2015-2518883 (Order entered May 23, 2018).
[7] https://www.governor.pa.gov/executive-order-2019-01-commonwealth-leadership-in-addressing-climate-change-and-promoting-energy-conservation-and-sustainable-governance/
[8] Pennsylvania Public Utility Commission, "*Electric Power Outlook for Pennsylvania 2017-2022*" (August 2018), *available at* http://www.puc.state.pa.us/General/publications_reports/pdf/EPO_2018.pdf

Reliability Corporation's ("NERC") 2017 assessment,[9] which found that system operators and planners need to gather data about "aggregate technical specifications of DERs connected to local distribution grids to ensure accurate system planning models, coordinated system protection, and real-time situation awareness," especially with expected growth in DERs.

Further, PPL Electric has been proactively preparing for increasing DER interconnections. The Company is actively engaged in assessing and understanding the impact of DER development through its Keystone Solar Future Project ("KSFP") and received a grant of over $3 million for this program from the U.S. Department of Energy's ("DOE") Office of Energy Efficiency and Renewable Energy through its Sunshot Initiative in August 2017. The objective of the project is to gain greater insights into operational and technical impacts on the distribution system as increasing amounts of customer-owned and third party-owned solar generation are integrated into the existing distribution system. As a part of the KSFP and to support PPL Electric's commitment, the Company developed and implemented a Distributed Generation ("DG") Portal, which is a user friendly web-based tool for rapid review of DG applications designed to provide best customers experience. Using this tool, PPL Electric's customers are able to submit their applications and receive quick responses from PPL Electric on their generation interconnection requests. These requests, which used to take several weeks or months to complete, are approved within one day for over 75% of the applicants due to the automated studies performed by the DG Portal.

[9] NERC 2017 Long-Term Reliability Assessment (Dec. 2017), *available at* https://www.nerc.com/pa/rapa/ra/reliability%20assessments%20dl/nerc_ltra_12132017_final.pdf

Further, PPL Electric has developed a Distribution Energy Resource Management System ("DERMS") to gather DER data, provide DER system forecast capabilities, and potentially provide DER management capabilities. The KSFP is an example of the Company's proactive approach to understanding and preparing for the opportunities and challenges presented by increased DER installations, so that PPL Electric can enable the smooth integration of DERs into its distribution system while maintaining system reliability.

In light of these financial incentives, legislative changes, political efforts, and Company initiatives, PPL Electric expects an increase in DER interconnection applications in the future. As explained previously, there are several activities – some promulgated by the market, some by government entities, and others by PPL Electric itself – to enhance and prepare for the future development of DERs within Pennsylvania. Efforts such as these demonstrate opportunities to increase DER installations within the Commonwealth. This increased solar generation and other types of DER on distribution systems will require careful and thoughtful planning by each EDC. Through the Company's Petition, PPL Electric seeks to proactively update its own processes and practices to integrate, monitor, and manage DERs on its distribution system.

Q. WOULD YOU PLEASE PROVIDE DETAILS ON THE COMPANY'S DER MANAGEMENT PLAN?

A. PPL Electric's DER Management Plan is designed to enable the Company to better integrate, monitor, and manage DER resources throughout PPL Electric's service territory. To that end, PPL Electric is proposing to require all new customer-owned and

third party-owned DERs that connect to the PPL Electric distribution system to comply with IEEE 1547-2018.[10] Specifically, after approval of this Petition, all new customer-owned and third party-owned DER system installations must be equipped with: (1) smart inverters; (2) DER management devices; and (3) local communication interfaces and protocols that meet IEEE 1547-2018. No new DER system will be approved for interconnection unless both a Company-approved smart inverter and a DER management device are included in the DER system interconnection application.

Q. PLEASE EXPAND ON THE SMART INVERTERS THAT WOULD BE REQUIRED UNDER THE COMPANY'S PROPOSAL.

A. Inverters are devices that convert the direct current ("DC") power produced by solar panels into the alternating current ("AC") power transported on the electric distribution system for use in homes and businesses. Smart inverters [11] provide additional functionality to standard inverters. For example, smart inverters are equipped with many grid support functions, including: (1) fixed power factor, volt/VAR, volt/watt, and reactive power; (2) frequency/watt; (3) low and high voltage and frequency ride through; and (4) power curtailment and remote ON/OFF capability. This functionality allows the DERs that utilize smart inverters to operate in "sync" with the distribution system, thereby reducing power quality issues and maximizing potential DER output and

[10] The IEEE and UL standards applicable to the Company's Petition are addressed in Ms. Reder's written direct testimony (PPL Electric Statement No. 2).

[11] The term "smart inverter" means an "inverter that performs functions that, when activated, can autonomously contribute to grid support during excursions from normal operating voltage and frequency system conditions by providing: dynamic reactive/real power support, voltage and frequency ride-through, ramp rate controls, communication systems with ability to accept external commands and other functions." PG&E Rule 21 Interconnection Tariff, *available at* http://www.cpuc.ca.gov/General.aspx?id=5071.

operability. Smart inverters are also used in battery (energy storage) systems, electric vehicle chargers, and any other technologies that use DC power.

Q. PLEASE OUTLINE THE DER MANAGEMENT DEVICES THAT WOULD BE REQUIRED UNDER THE COMPANY'S PROPOSAL.

A. A DER management device is the link between the DER inverters and the EDC. Under the DER Management Plan, DER management devices must be installed and connected to the local communication interface of the DER system, so that the Company can monitor and manage the DERs and take advantage of the DERs' grid support functions. Currently, PPL Electric envisions two types of DER management devices being used in conjunction with IEEE 1547-2018: (1) mesh network radios; or (2) cellular modems.

Mesh network radios are the proposed default communication device to be utilized for customer-owned and third party-owned DERs. Mesh network radios have the capability to connect wirelessly to the Company's new Radio Frequency ("RF") mesh network. By enacting a standard whereby DERs utilize mesh network radios, the Company will be able to seamlessly integrate DERs through its established RF mesh network. Given the robust nature of the RF mesh network already in place, this is the preferred communication device of PPL Electric.

Cellular modems will be used only in instances when a mesh network radio is not feasible. The Company has experience using cellular modems in its operations, as they are used by PPL Electric to communicate with equipment throughout its system, such as reclosers, sectionalizers, capacitor banks, and other forms of distribution automation equipment.

Because both RF mesh and cellular modem communication devices are operational on PPL Electric's system today, the Company is experienced with managing cybersecurity concerns associated with these communication devices. Robust practices and protocols are used to manage and provide cybersecurity. These practices and protocols are equal to or exceed industry standards and will be enhanced as necessary to address evolving threats. Further details on PPL Electric's cybersecurity practices and protocols related to the Company's Petition are addressed in Mr. Bayles's direct testimony (PPL Electric Statement No. 5).

Q. WOULD YOU PLEASE EXPLAIN IN DETAIL THE BENEFITS OF THE COMPANY'S DER MANAGEMENT PLAN?

A. PPL Electric's DER Management Plan is designed to provide several substantial benefits to customers, the Company, and the Commonwealth by improving the safety, quality, efficiency, stability, and reliability of the Company's operations and service while facilitating the increased deployment of DERs through the Company's service territory.

First, by enabling PPL Electric to monitor and manage the DERs, the amount of DERs that can be safely and reliably interconnected with the Company's electric distribution system can be significantly increased, as demonstrated in various industry research studies[12] and PPL Electric's internal study. Indeed, power factor management can increase the hosting capacity of the Company's electric distribution system, meaning

[12] *See* Seuss, J., *et al.*, "Improving Distribution Network PV Hosting Capacity via Smart Inverter Reactive Power Support" (July 2015), *available at* https://energy.sandia.gov/download/33230/;
Ding, F., *et al.*, "Technologies to Increase PV Hosting Capacity in Distribution Feeders" (July 2016), *available at* https://www.nrel.gov/docs/fy16osti/65995.pdf.

that PPL Electric can accommodate the interconnection of more DERs without the need for system upgrades. Currently, DER nameplate ratings are used to determine hosting capacity and, if required, determine system upgrades. With visibility of the DERs' actual output using the Company's DER Management Plan, planning efforts will yield in more precise analysis, thereby resulting in an increase of hosting capacity and a more accurate system assessment for upgrades. As a result, more customers will be able to interconnect DERs without triggering additional capital investments. Therefore, the Company's proposal is consistent with the several governmental and private initiatives encouraging the widespread deployment of DERs throughout Pennsylvania, which I noted previously in my testimony.

Second, allowing PPL Electric to monitor and manage DERs provides several safety benefits. When there is a disturbance or an outage on the system, PPL Electric will be able to better determine the output of impacted DERs and enable the Company's system operators to safely perform system restoration without violating any equipment constraints and improve reliability. Moreover, if necessary, PPL Electric could remotely curtail the DERs in the vicinity of the Company's employees who may be working nearby and keep the distribution lines de-energized during maintenance and repair work.

Additionally, depending on the characteristics of the circuit, a delay or failure to trip off could lead to unintentional islanding of the DER. This unintentional islanding occurs when the generation from the DERs is strong enough to supply the load when isolated from the distribution system. Such a situation presents a significant safety risk to both the public and PPL Electric's employees and contractors. If crews are dispatched to repair equipment and see a visible break in the Company's protective equipment, they

cannot assume the downstream line is de-energized. If the unintentional island has formed, the lines will be energized downstream of this device, which can be a safety hazard to line workers and the public. If there are downed conductors, the DER can backfeed into this low impedance fault and can cause fires or electrical hazards to the public. Also, when unintentional islanding occurs, there is no way for the utility to maintain power quality, which can lead to customers' equipment being damaged. Currently, PPL Electric has no way of detecting if an unintentional island forms or de-energizing DERs to remove the island. However, the Company's Plan would enable PPL Electric to locate and disconnect DERs in these unintentional islanding scenarios.

Third, by utilizing the grid support functionality, PPL Electric can improve system efficiency. Indeed, enabling localized power generation improves system efficiency by reducing line losses. This is because power would be generated locally instead of being generated at utility-scale generation facilities and transported across transmission and distribution lines to end-use customers.

Fourth, the Company's proposal can improve power quality at customer sites and on distribution circuits by leveraging DER voltage support functions, potentially avoiding the need to deploy traditional voltage regulation infrastructure. Specifically, power factor, Volt/VAR, Volt/Watt, ramp rates,[13] and reactive power functions allow DERs to maintain appropriate voltage levels on the distribution system. As a result, the Company will be able to reduce DER interconnection system upgrade costs and reduce the need to deploy

[13] Inverters can change the rate at which the generation output ramps up to full capacity when the solar irradiance becomes present. The default setting for this parameter is 100%, which means when clouds give way to sunshine, the inverter ramps from almost no output to the full amount allowed by the solar resource. Given the intermittent nature of solar irradiance, inverters ramping up quickly can lead to power quality issues in high penetration scenarios, such as flicker or spikes in voltage.

equipment, such as voltage regulators, to manage voltage irregularities. Similarly, frequency/watt functionality allows a DER to maintain appropriate grid frequency, thereby improving the stability of the distribution system and the DER's ability to maintain a connection with the distribution system.

Fifth, the DER Management Plan will improve system stability and reliability. Smart inverters with IEEE 1547-2018 capabilities provide DERs with the ability to "ride through" low and high voltage and frequency events. As a result, DERs will be more likely to remain online and operating properly during abnormal voltage and frequency disturbances occurring on the distribution or transmission system, thereby maintaining reliable service. Inverters without a setting for this functionality traditionally "trip off" DERs when a system disturbance occurs. In higher solar PV penetration scenarios, large numbers of inverters going offline due to a deviation from normal distribution system operating parameters can exacerbate the stress on existing infrastructure and negatively affect service reliability. Keeping DERs online during short-term system interruptions can mitigate system imbalances between load and generation resources and can reduce the likelihood of more significant disturbances to the system.[14] Additionally, if a substantial number of DERs trip offline simultaneously, they could destabilize the bulk electric system and increase the likelihood of a cascading outage. With ride-through capabilities, however, DERs can help support the bulk electric system rather than exacerbating the problem. DER's impact on system stability was evident during the

[14] The importance of this functionality is highlighted by a recent initiative between the Department of Energy's Argonne National Laboratory and PJM's Distributed Energy Resource Ride-Through Task Force. These groups have entered into agreement to study the ride-through and trip guidelines per IEEE 1547-2018 and adjust the rules to better manage rooftop solar energy resources. *See* http://insidelines.pjm.com/pjm-and-argonne-national-lab-working-to-fine-tune-guidelines-for-solar/.

August 9, 2019 black out in the United Kingdom, which affected a total of 1.1 million customers. During this cascaded event that started with a transmission disturbance, a total of approximately 500 MW of DER generation was unexpectedly lost due to protection settings inside the inverters without EDCs even knowing about it and, therefore, further increasing the total customers impacted by the event. [16]

Further, allowing PPL Electric to monitor and manage DERs eliminates the issue of "load masking"[15] because it provides real time visibility into individual and aggregate DER generation output. With the ability to have real-time visibility to DER generation and an understanding of masked load, PPL Electric can more effectively design and operate the system. For example, when there is a disturbance on the system, PPL Electric will be able to accurately determine the actual electric demand on a circuit without the contribution from DERs and act accordingly. This allows the Company's system operators to safely perform system restoration without violating any equipment ratings or constraints such as current or voltage limits.

Finally, apart from the general system benefits, the DER Management Plan will provide benefits to individual DER customers. For example, currently, when inverters trip offline due to grid disturbances, they remain offline for as long as five minutes after power is restored. As a result, the customer-generators' output and credits are reduced over the life-cycle of the system. However, inverters that comply with IEEE 1547-2018 can remain online during certain grid disturbances by utilizing fault ride through and momentary cessation functionalities.

[15] As used in this Petition, "load masking" means the difference between the amount of electricity flowing through PPL Electric's distribution lines and the totality of electric demand from its customers as some of the demand is being served by electricity generated by local DERs.
[16] National Grid ESO LFDD 09/08/2019 https://www.nationalgrideso.com/document/152346/download

Thus, the DER Management Plan is designed to produce several substantial benefits for customers, the Company, the Commonwealth, and PJM Interconnection LLC.

Q. YOU MENTIONED THE BENEFITS ASSOCIATED WITH VOLTAGE MANAGEMENT UNDER THE COMPANY'S PROPOSAL. COULD YOU PLEASE ELABORATE?

A. Modern grids are challenged in several ways to host a significant penetration of DERs. One of the most difficult challenges for distribution grid operators is to manage voltage rise. Traditional distribution systems were designed to supply electricity in a single direction from the generator to consumer which allows for the voltage to steadily drop as it moves from substation to customer. Historically, the biggest voltage concern with the traditional distribution feeder design is avoiding voltage sag for customers who are served at the end of a long feeder.

Today, and in the future, DER technologies must export electricity onto the distribution system at a higher voltage than their local supply. As a result, distribution systems with DERs are now beginning to see significant overvoltage events occurring during midday when PV generation is highest and solar inverters push up local voltages. In circumstances where the DER penetration levels are high, a reversal of power flow could occur where generation from DER pushes back into the transmission system creating a challenge for the current grid protection schemes, since they are designed to protect against one-way power flow. The voltage variability and power flow abnormalities pose new-found operational complexities and technical challenges for grid operators. With approval of the Petition, PPL Electric will have the ability to monitor

and manage the operational variability caused by significant DER penetration levels before it becomes a costly distribution challenge.

If rising voltage levels are not managed well, the Company's customers may suffer because system-wide costs to mitigate them will increase. Furthermore, maintaining a safe customer voltage is critical so that consumer-owned electronics are not damaged, operate inefficiently, or fail from high voltage. Specific high voltage impacts include:

1. Consumer appliances degrade at a faster rate. As appliance electrification increases and consumers invest more in expensive electronic assets, high voltage will become increasingly problematic.

2. When hosting capacities are finally reached, consumers may be restricted from implementing new DERs. Ms. Reder provides details these issues in PPL Electric Statement No. 2.

3. If PPL Electric needs to make costly grid investments to regain control of voltage and power quality as a result of DER penetration, customers' base rates could rise across the system to accommodate the upgrades. Ms. Reder provides details on this topic in PPL Electric Statement No. 2.

C. THE COMPANY'S PROPOSED TARIFF MODIFICATIONS

Q. PLEASE DESCRIBE THE TARIFF MODIFICATIONS THAT PPL ELECTRIC IS PROPOSING IN THIS PROCEEDING.

A. PPL Electric has proposed to establish a new rule in its retail tariff entitled "Rule 12 – Distributed Energy Resources Interconnection Service" or "DERIS." Attached to my

testimony as PPL Electric Exhibit SS-1 is a copy of the *pro forma* tariff supplement filed by the Company with its Petition setting forth the new DERIS tariff rule.

The DERIS provides customer application details and technical DER equipment standards under the DER Management Plan. Specifically, these tariff pages provide details about the device requirements, including smart inverters, DER management devices, and DER monitoring and management. I note that the hyperlinks in the *pro forma* tariff supplement are not live yet, and the actual URLs may change during the course of the proceeding.

D. THE COMPANY'S PROPOSED WAIVERS OF REGULATIONS

Q. PLEASE DESCRIBE THE WAIVERS OF REGULATIONS THAT PPL ELECTRIC IS PROPOSING IN THIS PROCEEDING.

A. To implement the Company's DER Management Plan, the Company has requested waivers of various Commission regulations. Specifically, the Company requests waivers of all or portions of the following regulations: 52 Pa. Code §§ 75.13(c), 75.13(k), 75.22, 75.34, 75.35, 75.37, 75.38, 75.39, and 75.40. These regulations are all related to the Company's proposal of new DERs being equipped with smart inverters. In fact, as seen below, the Company is seeking waivers of many of these regulations because they require the inverters to be "certified," which as presently defined by the Commission's regulations means that they meet the current IEEE 1547 and UL 1741 standards.

First, Section 75.13(c) provides, in pertinent part that "[a]n EDC shall file a tariff with the Commission that provides for net metering consistent with this chapter." 52 Pa. Code § 75.13(c). As part of this Petition, the Company proposes to implement tariff

modifications that could be construed as not being consistent with Chapter 75. Therefore, I have been advised by counsel that a waiver of Section 75.13(c) may be needed to implement the DER Management Plan.

Second, Section 75.13(k) states, in pertinent part, that "[t]he EDC and DSP may not require additional equipment or insurance or impose any other requirement unless the additional equipment, insurance or other requirement is specifically authorized under this chapter or by order of the Commission." 52 Pa. Code § 75.13(k). Here, the Company will require new customer-generators to install additional equipment (*i.e.*, the DER management device) and impose additional requirements (*e.g.*, that the customer-generator allow PPL Electric to monitor and manage the DER and that the DER utilize a standardized, non-proprietary communications protocol specified by the utility) that are not specifically authorized under Chapter 75 or a Commission order. Therefore, I have been advised by counsel that PPL Electric has requested a waiver of Section 75.13(k), which is necessary to implement the DER Management Plan.

Third, Section 75.22 of the Commission's regulations defines several terms that are used in Subchapter C of Chapter 75 of the Commission's regulations. Among those terms is "Certified," which is defined as:

> A designation that the interconnection equipment to be used by a customer-generator complies with the following standards, as applicable:
>
> (i) IEEE Standard 1547, ''Standard for Interconnecting Distributed Resources with Electric Power Systems,'' as amended and supplemented.

(ii) UL Standard 1741, ‘‘Inverters, Converters and Controllers for use in Independent Power Systems’’ (January 2001), as amended and supplemented."

Fourth, Section 75.34 of the Commission's regulations sets forth when the Levels 1, 2, and 4 interconnection review procedures shall be used, which for Levels 1 and 2 includes when "[t]he customer interconnection equipment proposed for the small generator facility is certified." 52 Pa. Code § 75.34(1)(ii), (2)(iii).

Fifth, Section 75.35 of the Commission's regulations provides that "[t]he technical standards to be used in evaluating all interconnection requests under Level 1, Level 2, Level 3 and Level 4 reviews, unless otherwise provided for in these procedures, are IEEE 1547 and UL 1741, as they may be amended and modified." 52 Pa. Code § 75.35.

Sixth, Section 75.37 of the Commission's regulations sets forth the Level 1 interconnection review procedures. The regulation prescribes that "[a]n EDC may not impose additional requirements for Level 1 reviews not specifically authorized under this subchapter." 52 Pa. Code § 75.37(a). Moreover, "[f]or interconnection of a proposed small generator facility to the load side of spot network protectors," the regulation requires that "[t]he customer interconnection equipment proposed for the small generator facility . . . be certified." 52 Pa. Code § 75.37(b)(2).

Seventh, Section 75.38 of the Commission's regulations provides the Level 2 interconnection review procedures. The regulation states that "[a]n EDC may not impose additional requirements for Level 2 reviews not specifically authorized under this subchapter." 52 Pa. Code § 75.38(a). Additionally, "[f]or interconnection of a proposed

small generator facility to the load side of spot network protectors," the regulation requires that "[t]he customer interconnection equipment proposed for the small generator facility . . . be certified." 52 Pa. Code § 75.38(b)(2).

Eighth, Section 75.39 of the Commission's regulations outlines the Level 3 interconnection review procedures, which can apply to small generator facilities that are less than 5 MW, "not certified," and "noninverter based." 52 Pa. Code § 75.39(a)(1)-(3).

Ninth, Section 75.40 of the Commission's regulations sets forth the Level 4 interconnection review procedures. Subsection (c) specifies the procedures for reviewing an interconnection request from a customer who wants the generating facility "interconnected to the load side of an area network." 52 Pa. Code § 75.40(c). Such procedures are to be used "notwithstanding any conflicting requirements in IEEE Standard 1547." 52 Pa. Code § 75.40(c). Subsections (c)(1)(ii) and (c)(5)(ii) require the proposed small generator facility to use "a certified inverter-based equipment package for interconnection." 52 Pa. Code § 75.40(c)(1)(ii), (c)(5)(ii). Subsection (d) also sets forth the review procedures and criteria for a requested "interconnection to circuits that are not networked." 52 Pa. Code § 75.40(d).

I have been advised by counsel that waivers of all or portions of Sections 75.13(c), 75.13(k), 75.22, 75.34, 75.35, 75.37, 75.38, 75.39, and 75.40 may be needed to implement the DER Management Plan because PPL Electric will require DERs to meet IEEE 1547-2018, which is dependent upon forthcoming updates to UL Standard 1741. Indeed, although the relevant revisions to IEEE Standard 1547 have been made, UL Standard 1741 is still under revision. Until UL Standard 1741's revisions are published, there is no standardized testing for manufacturers to certify that their inverters meet IEEE

1547-2018. In the absence of the revised UL Standard 1741, the Company will use its interim solution, which is described in Ms. Reder's written direct testimony (PPL Electric Statement No. 2). Therefore, to the extent that the new UL Standard 1741 is not published by the time the Commission approves the Company's Petition, PPL Electric has requested a waiver of the Commission's requirement that "certified" comply with the 2016 version of UL Standard 1741.

E. THE PROPOSAL'S ABILITY TO LEVERAGE THE COMPANY'S PRIOR INVESTMENTS, EXISTING TECHNOLOGIES, AND INNOVATION

Q. COULD YOU PLEASE EXPLAIN HOW THE DER MANAGEMENT PETITION WILL LEVERAGE THE COMPANY'S PREVIOUS INVESTMENTS AND EXISTING TECHNOLOGIES?

A. Unlike other utilities, PPL Electric is well-positioned to implement this DER Management proposal due to its ability to take advantage of prior investments and existing technologies implemented by the Company. To successfully facilitate increased levels of DER deployments, PPL Electric needs the ability to monitor and manage the DER assets, which requires a link with a distribution management system ("DMS"). Here, PPL Electric has already deployed an industry leading DMS that is prepared to be utilized as a link with customers' DERs. Further, enabling DERs to interconnect and integrate seamlessly with the grid involves implementing a DERMS, which is a grid control optimization system. The DERMS platform incorporates DERs and offers functionality such as Volt/VAR optimization (VVO), power quality management, and DER coordination to support operational needs. As

part of the KSFP, PPL Electric developed a DERMS, which originally became operational in October 2019. Because the DERMS provides grid operators with the capability to monitor and manage DER assets, PPL Electric is prepared to implement and execute the DER Management Plan.

In addition, as explained previously, PPL Electric plans to use its existing RF Mesh network as part of its DER Management Plan. The RF Mesh network was deployed in accordance with the Company's Commission-approved Smart Meter Plan, Act 129 of 2008, and the Commission's related orders. By taking advantage of the existing RF Mesh network, the Company is expanding the benefits of the investments in this network that have been paid for by ratepayers. Leveraging investments already made by PPL Electric, such as DERMS and the RF Mesh network, places PPL Electric in a position where the Company will only have to invest approximately $330,000 to implement the DER Management proposal.[16]

Looking forward, PPL Electric plans to integrate DERMS with a more Advanced Distribution Management System ("ADMS"). ADMS will include a common graphical user interface that combines distribution management system functions for control room operations, outage management, SCADA, distributed energy resource management, and Volt/VAR optimization. DERMS and ADMS leverage the same network model and power flow to validate DER dispatch

[16] At this time, PPL Electric estimates an additional $100,000 of capital investments may be required to implement updates to PPL Electric's Renewable Energy Connection to support the new tariff requirement after the Company's DER Management Petition is approved by the Commission. PPL Electric also anticipates the following potential (but not required) investments: (1) $200,000 to repackage existing versions of DER management devices; and (2) $30,000 to purchase inverters to develop and test communication conversion protocol.

PPL Electric is not requesting any ratemaking findings as part of this proceeding, including whether these projected capital investments should be recovered by the Company. Such ratemaking issues will be addressed in a future base rate proceeding.

schedules, which will enable PPL Electric to better manage the grid complexity that will come from increased levels of DER deployments.

Thus, PPL Electric is appropriately and uniquely prepared to successfully execute the DER Management Plan.

Q. ARE THERE OTHER REASONS WHY PPL ELECTRIC IS WELL-POSITIONED TO IMPLEMENT THE COMPANY'S PROPOSAL?

A. Yes. PPL Electric consistently strives to provide safer and more reliable service to its customers. As DERs become more prevalent in Pennsylvania, the Company recognizes the importance of adapting to meet customers' evolving needs, which is one of the reasons why the Company filed the DER Management Petition. In fact, the Company's history of customer satisfaction is exemplary. In June 2019, PPL Electric received the J.D. Power residential customer satisfaction award for large electric utilities in the eastern United States for the eighth year in a row.

In addition, PPL Electric has a proven track record of being a successful innovator in the utility industry that sets it apart from other utilities. The Smart Electric Power Alliance ("SEPA") named PPL Electric as the Investor-Owned Utility of the Year for 2019 due to the Company's development of the DERMS. Further, the Company received the Association of Edison Illuminating Companies' ("AEIC") 2019 Achievement Award for PPL Electric's groundbreaking, first-of-its-kind downed wire safety technology. Moreover, PPL Electric was one of only 19 utilities in the entire country, and the only Pennsylvania electric utility, to be named as one

of *Public Utilities Fortnightly*'s Top Innovators of 2019.[17] Therefore, PPL Electric is well-positioned to build upon its past successes and implement the DER Management proposal.

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

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

[17] *See* https://www.fortnightly.com/fortnightly/2019/11-0/fortnightly-top-innovators-2019.

PPL Electric Exhibit SS-1

PPL Electric Utilities Corporation

RULES FOR ELECTRIC SERVICE
RULE 12 - DISTRIBUTED ENERGY RESOURCE (DER) INTERCONNECTION SERVICE

A. PURPOSE

The Distributed Energy Resource Interconnection Service (DERIS) shall be applied to all new DER interconnections to the distribution system to enable the Company to monitor and manage the flow of electric energy from DER resources to the distribution system. DER resources shall include inverter-based alternative energy sources and systems, as defined in the Alternative Energy Portfolio Standards Act of 2004 (73 P.S. §§ 1648.1 – 1648.8), and storage resources (batteries).

B. APPLICATION

(1) This Rule shall apply to all DER resources interconnected to the distribution system on or after XXXX (date the application is approved).

(2) It shall apply to all customers who receive Basic Utility Supply Service under Rate Schedules RS, GS-1, GS-3, and LP-4.

C. DEVICE REQUIREMENTS

(1) Renewable Energy Connection – The online portal allows customers to apply to interconnect the DER Management and Communication devices with the distribution system. Refer to the REMSI Renewable Energy Connection under PPL Electric's Electric Rates and Rules for additional information. https://www.pplelectric.com/utility/about-us/electric-rates-and-rules.aspx

(2) Smart Inverters – All inverters connected to the distribution system must comply to the UL 1741 safety certification and be capable of utilizing smart functions for grid support. In addition, these systems must have communication capabilities for monitoring and managing the DER in accordance with IEEE Standard 1547-2018 and UL Standard 1741 as amended and supplemented unless otherwise approved by the Pennsylvania Public Utility Commission. A list of approved smart inverters is provided in the REMSI link under PPL Electric's Electric Rates and Rules: https://www.pplelectric.com/utility/about-us/electric-rates-and-rules.aspx

(Continued)

DISTRIBUTED ENERGY RESOURCE (DER) INTERCONNECTION SERVICE (Continued)

C. DEVICE REQUIREMENTS (Continued)

(3) DER Management Device - All DER resources whether Customer-Owned or Third Party-Owned that are applying to interconnect with PPL Electric's distribution system must install smart inverters as defined in Rule 12C(2). Additionally, a DER Management Device will be directed by the Company and must be installed and connected to the data port of the smart inverter. The communication medias with the DER Management Device may use either: (1) Meter Network radios connected wirelessly to PPL Electric's RF mesh network or (2) Cellular Modem. Cellular modems will be permitted only in instances when a mesh network radio is not feasible, as determined at the sole discretion of the Company. These devices shall be installed and maintained in accordance with Company's "Rules for Electric Meter and Service Installations (REMSI)". Refer to the REMSI DER Management Device section for additional information.

(4) DER Monitoring and Management – By installation of an approved DER system in accordance with device requirements under Rule 12C(2) and Rule 12C(3), customer and owner agree to allow PPL Electric to monitor and manage the DER system in accordance with Company policy and the PA PUC's approval at Docket No. P-2019-3010128.

VERIFICATION

I, SALIM SALET, being the Director - Operations at PPL Electric Utilities Corporation, 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: 12/10/2019

Salim Salet