



PPL Electric Utilities

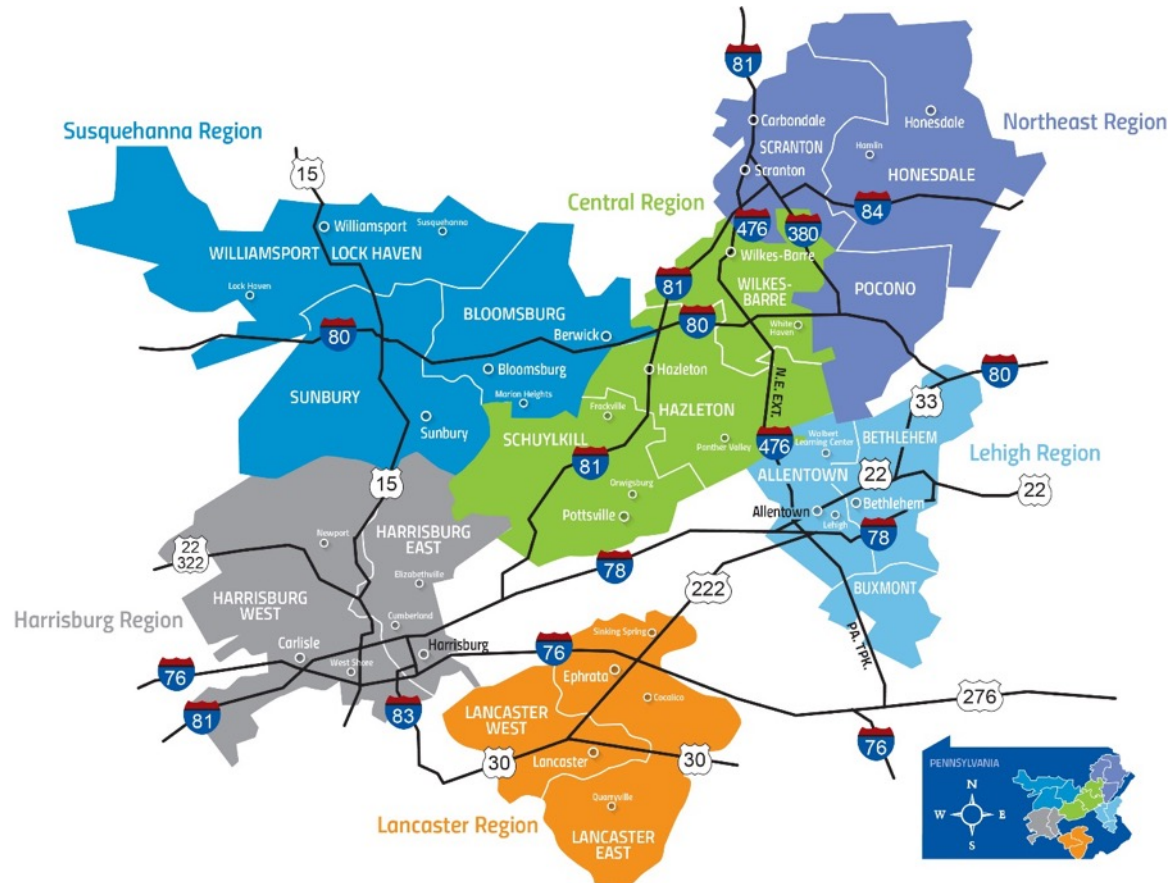
We Deliver.

Impacts of DERs on the Distribution System

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We are an electric delivery company

- 10,000-square-mile service area
- Approximately 1.4 million customers
- Tremendous increase in DER

Electric Power Industry is Transforming



Distributed Energy Resources: Economically competitive smaller, distributed power systems and storage are being installed in increasing numbers.

Energy Efficiency: Consumption of energy is being reshaped by technologies that drive efficiency and change demand patterns.

Decarbonization: Low-carbon technologies such as wind and solar are exceeding growth expectations.

Digitization: Asset, facility and fleet level, internet-enabled applications are proliferating.



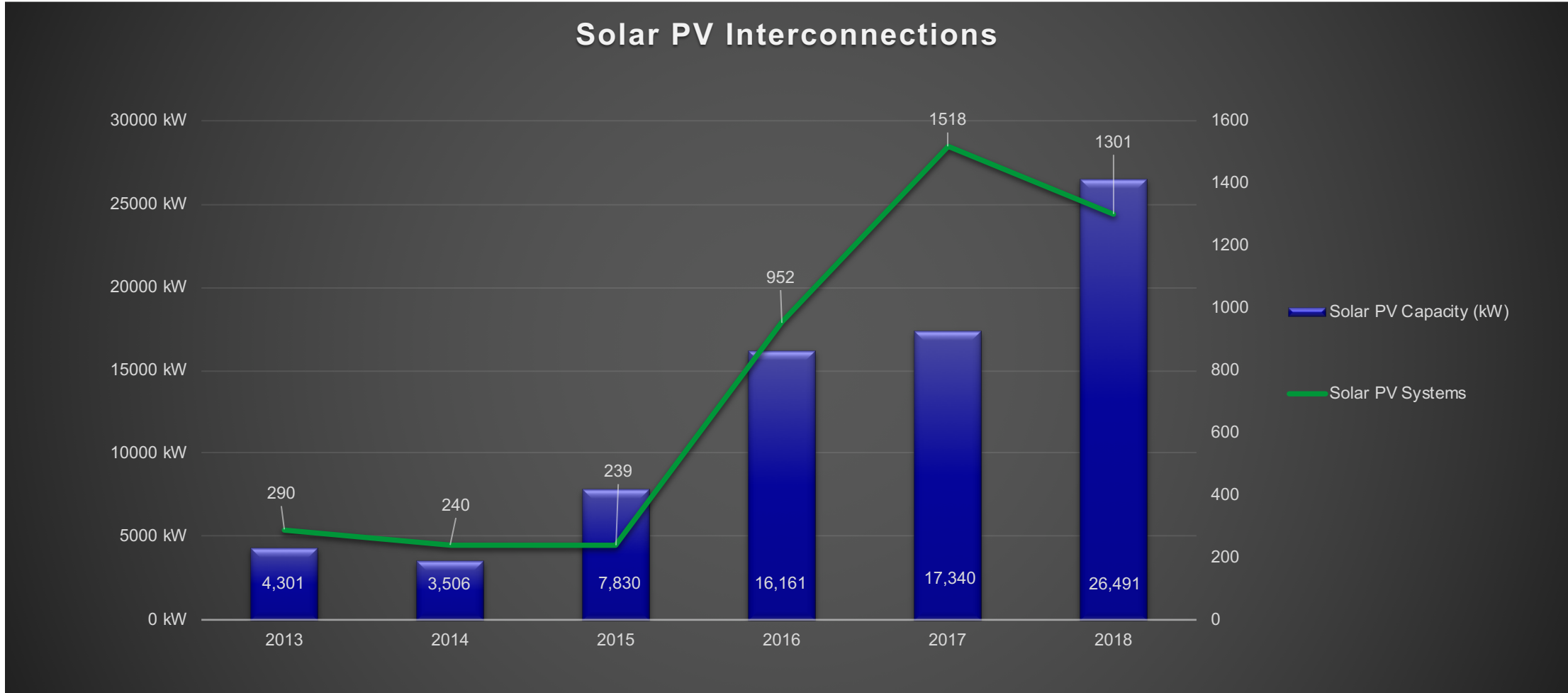
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Electric Power Industry Transformation

- Distributed power technologies have created the need for two-way power flows.
- New technologies such as batteries are providing opportunities throughout the transmission and distribution network.
- It is imperative that PPL begins testing the management of DER systems



Growth of Customer DER



Changes Require Investments

Challenges

- Masked (Hidden) Load
 - Fault Location
 - Load Transfers
- Traditional Protection Methods
 - 69kv Substation Blown Fuse Detection
 - Inverter Fault Currents
- Cyber Security
 - Connected Systems
 - Aggregated Systems

Solutions

- Advanced Metering Infrastructure
 - Inverter Communication
- DERMS
- Microprocessor Relays
- 69kV Reclosers and Breakers
- DER Forecasting Tools

Opportunities

- Non-Wire Alternatives
- More discretely controllable Grid
 - Voltage
 - VARs
- Market Enablement

Keystone Solar Future Project

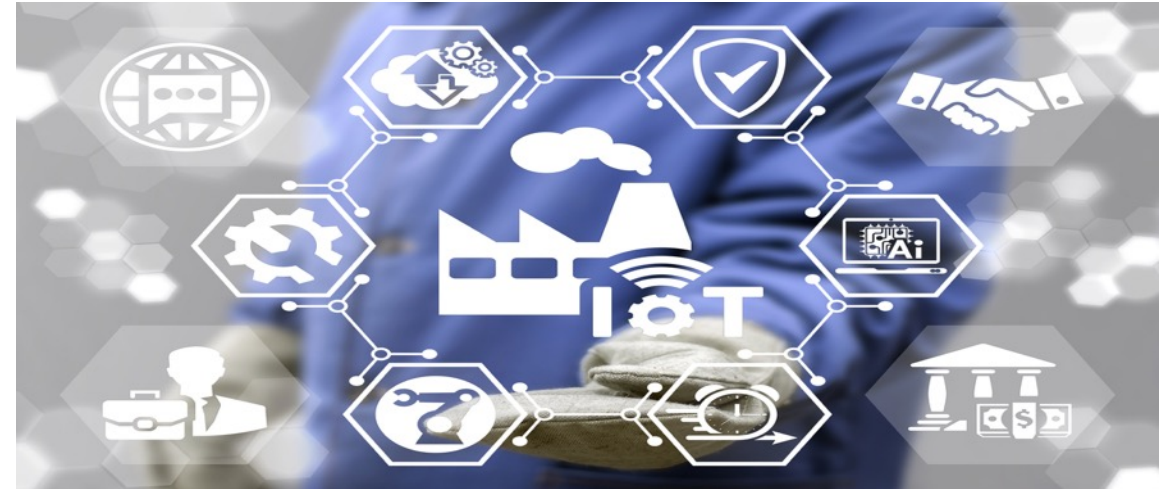


An innovative pilot that will allow PPL system operators to have remote monitoring and control of the DER systems

- **Interconnection Web Portal:** Renewable Energy Connection
- **DERMS:** Central platform with Distributed Energy Resource-aware algorithms for management and optimization.
- **Proof of Scalability:** Customer enrollment, DERMS pilot, technology demonstration, Drexel simulation.

Non-wires alternatives

- More efficient utility investment to keep customer rates reasonable
 - Ability to defer or eliminate capital investments
- Energy storage
- Demand response
- Voltage optimization
- Grid management
- Energy efficiency



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