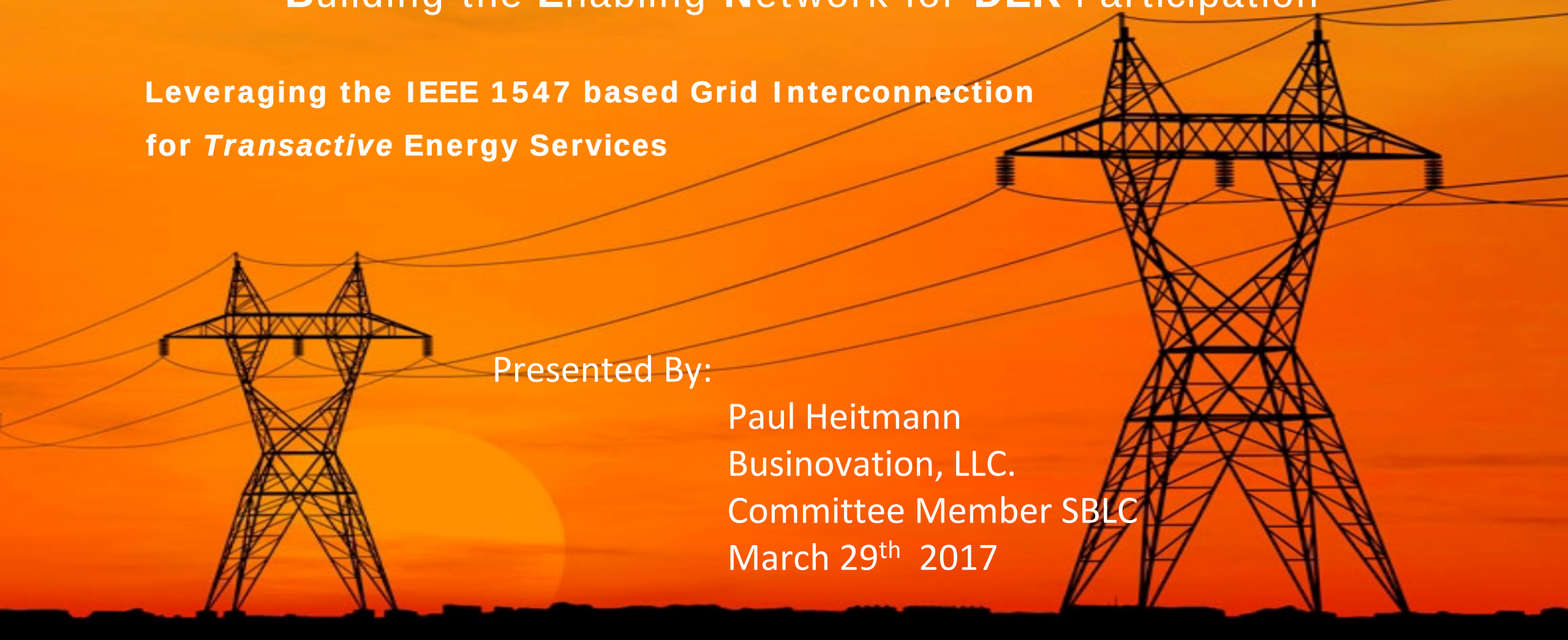
IEEE STANDARDS ASSOCIATION

IEEE

The Drive To Transactive Energy

Building the Enabling Network for DER Participation

Leveraging the IEEE 1547 based Grid Interconnection for *Transactive* Energy Services



Presented By:

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Businovation, LLC.
Committee Member SBLC

March 29th 2017

The Drive Toward Standards-Based Transactive Energy (TE) Solutions

- The IEEE Standards framework re: Distributed Energy Resources
- Energy Management Methods that enable TE
- Conformity Assessment: Ensuring Platform Scalability

The world's largest professional association

Advancing Technology for Humanity

Global Reach

426,000+ Members

160+ Countries

1,600+ Annual Conferences

Technical Breadth

39 Technical Societies

6 Technical Councils

3,500,000 Technical Documents

180+ Top-cited Periodicals

- Aerospace and Electronic Systems
- Antennas and Propagation
- Biometrics Council
- Broadcast Technology
- Circuits and Systems
- Communications
- Components, Packaging, and Manufacturing Technology
- Computational Intelligence
- Computer
- Consumer Electronics
- Control Systems
- Council on Electronic Design Automation
- Council on Superconductivity
- Dielectrics and Electrical Insulation
- Education
- Electron Devices
- Electromagnetic Compatibility
- Engineering in Medicine and Biology
- Geoscience and Remote Sensing
- Industrial Electronics
- Industry Applications
- Information Theory
- Instrumentation and Measurement
- Intelligent Transportation Systems
- Magnetics
- Microwave Theory and Techniques
- Nanotechnology Council
- Nuclear and Plasma Sciences
- Oceanic Engineering
- Photonics
- Power Electronics
- Power & Energy
- Product Safety Engineering
- Professional Communications
- Reliability
- Robotics and Automation
- Sensors Council
- Signal Processing
- Social Implications of Technology
- Solid-State Circuits
- Systems, Man, and Cybernetics
- Systems Council
- Technology and Engineering Management
- Ultrasonics, Ferroelectrics, and Frequency Control
- Vehicular Technology

(2)

Complete Business Lifecycle

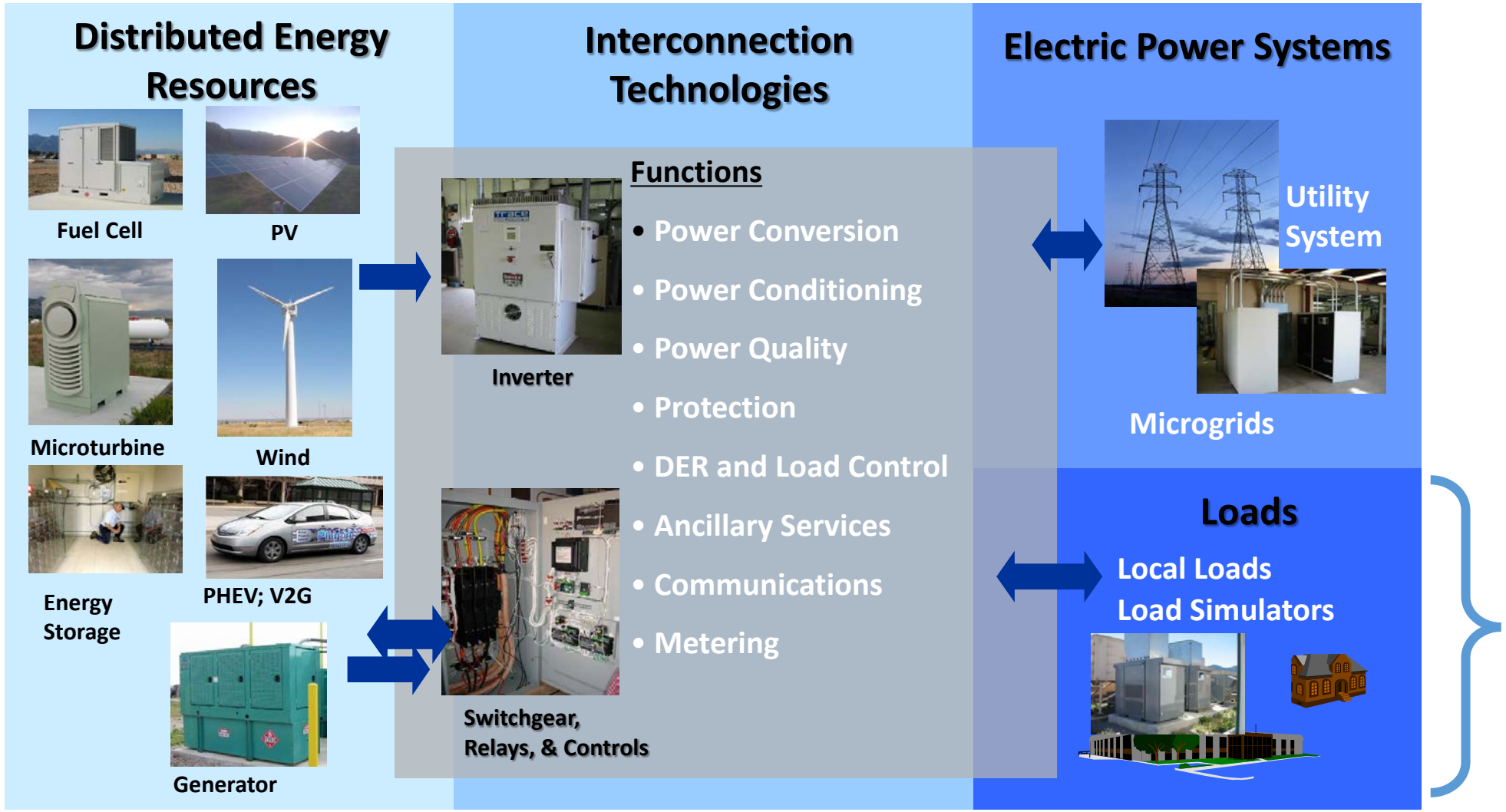
IEEE 1547

IEEE 2030

Apps	Apps
2030	
1547	

IEEE-SA provides industry a framework of solutions to ensure rapid introduction of new technologies to market

Distributed Energy Resources Interconnection



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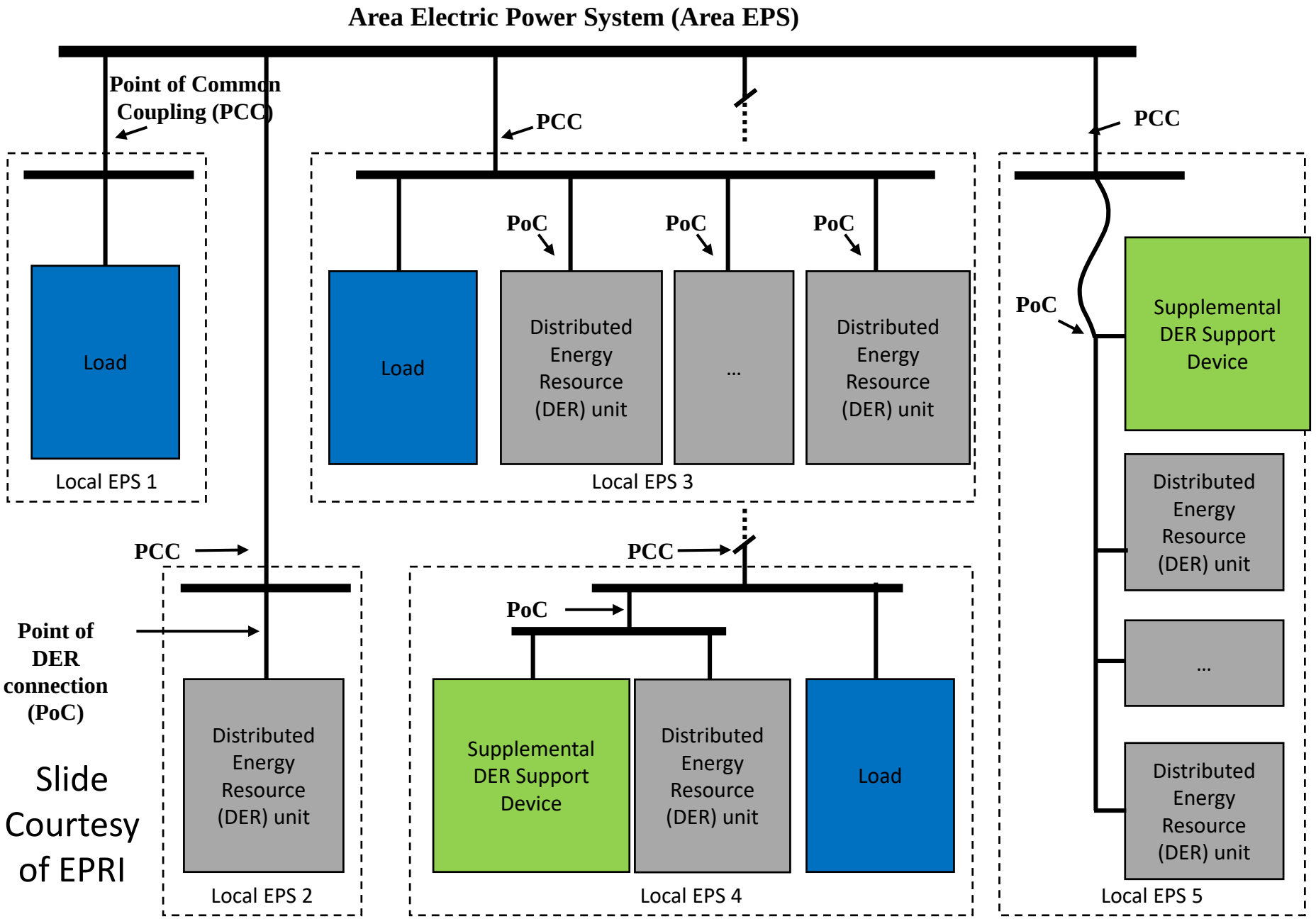
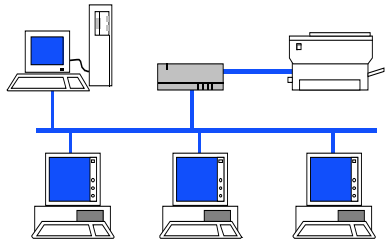


Slide Courtesy of EPRI

DER Related Standards

Some Areas Covered

- Interoperability
- Networking and Communications (including the home)
- Cyber Security
- Substations Automation
- Distribution Automation
- Renewables
- AMI
- Power Quality and Energy Efficiency
- Electric Vehicles



Compliance Testing Spectrum (can drive adoption)

Type | Production | Install | Commissioning | LifeCycle

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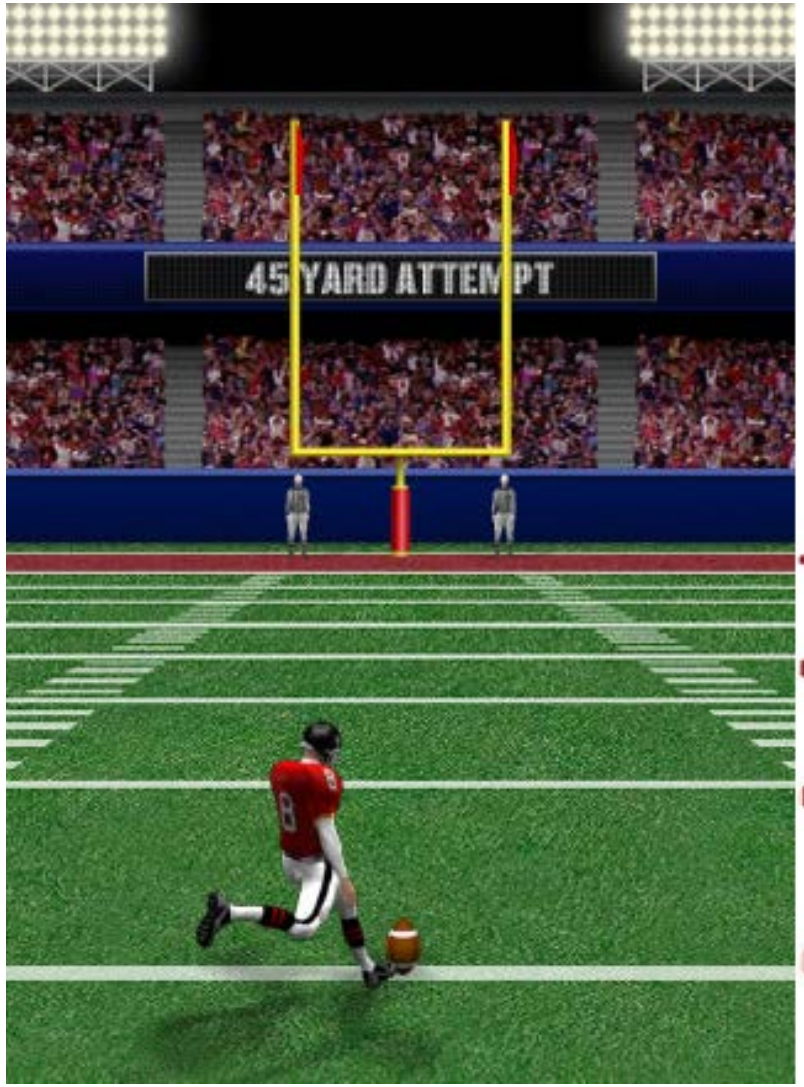
The Playing Field – The Drive Toward TE



EXAMPLES OF ENERGY SOLUTIONS (OR USE PROFILES) THAT POINT TO VARIOUS EVOLUTIONARY PATHS TOWARD GRID PARTICIPATION OF POWER ELECTRONICS

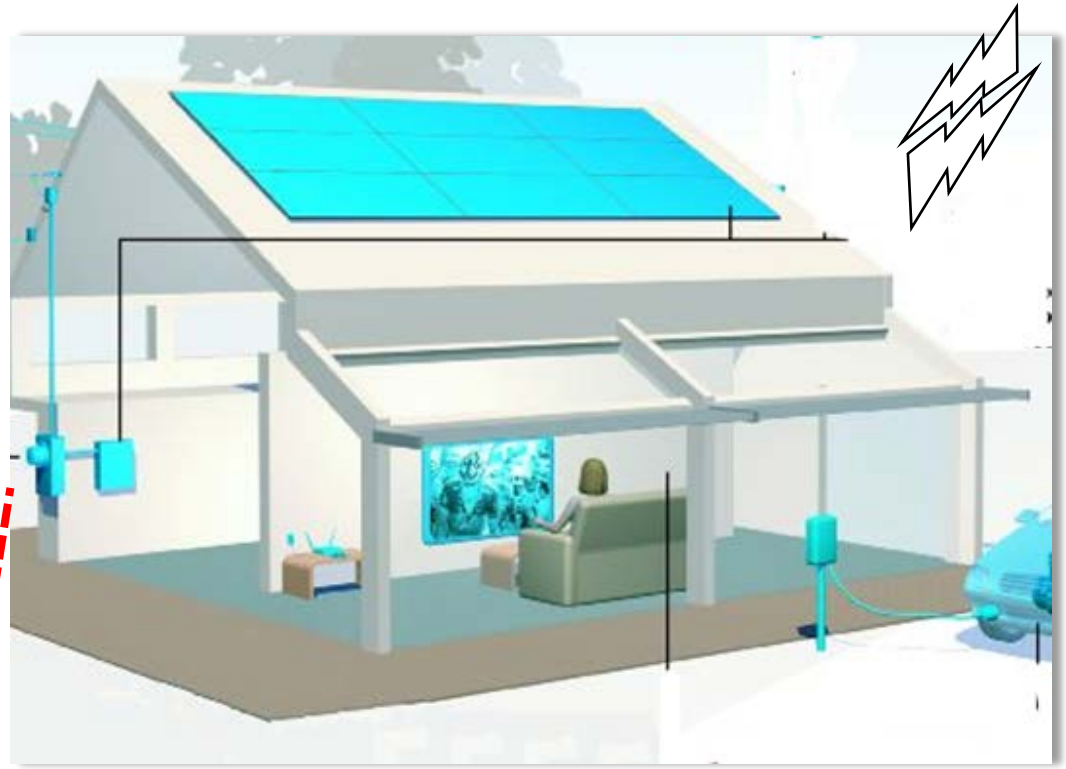
FULL TRANSACTIVE (PREDICTIVE)

PARTIAL TRANSACTIVE (PROACTIVE)

NET ENERGY METERING (PERMISSIVE)

RESPONSIVE LOAD (REACTIVE)

Advancing Downfield



RESPONSIVE LOAD (REACTIVE)

NET ENERGY METERING (PERMISSIVE)

TRANSACTIVE ENERGY (PROACTIVE)

Energy STAR Connect

- Increasing Intelligence found in devices and appliances
- Advances in network connectivity (IoT)
- Increasing ubiquity, persistence and precision of Control Signals
- Standardization of Interfaces and Data Models

ENERGY STAR Program Requirements
Product Specification for Connected Thermostat Products

Eligibility Criteria
Version 1.0

Following are the eligibility requirements for the Version 1.0 ENERGY STAR Connected Thermostats program. Connected Thermostat (CT) products shall meet all of the identified criteria to earn the ENERGY STAR.

1) Definitions:

A. Communication Link: The mechanism for bi-directional data transfers between the CT device and one or more external applications, devices or systems.

B. Connected Thermostat Device: A device that controls heating, ventilation, and air-conditioning (HVAC) equipment to regulate the temperature of the room or space in which it is installed, and has the ability to communicate with sources external to the HVAC system. For connection, the CT device may rely on a Wi-Fi home area network and an internet connection that is independent of and not part of the CT Device. Where the CT device relies upon other devices that are not reasonably expected to be in the home, e.g. Zigbee gateway, these devices are part of the CT device.

C. Connected Thermostat Product: For the purposes of this specification, the CT product includes the CT device in the home with associated firmware, which is assumed to be updated during the time the CT device is used in the home, as well as a CT service supported by hardware and software outside of the home. The CT service would typically provide web and smart phone based thermostat control. See Figure 1 for a pictorial representation. Functions in the left-most group must be physically located in the home. Functions in the middle group commonly operate using a combination of hardware that is physically located within the home and services that rely fully or partially on communication with the cloud. The functions on the right typically reside in the cloud.

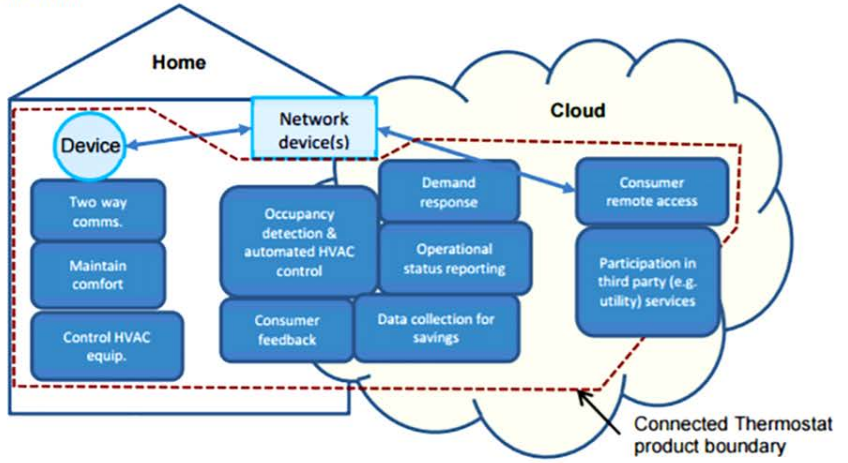


Figure 1: Connected Thermostat Product

Example: IEEE1547 (2017 Revision- pending)

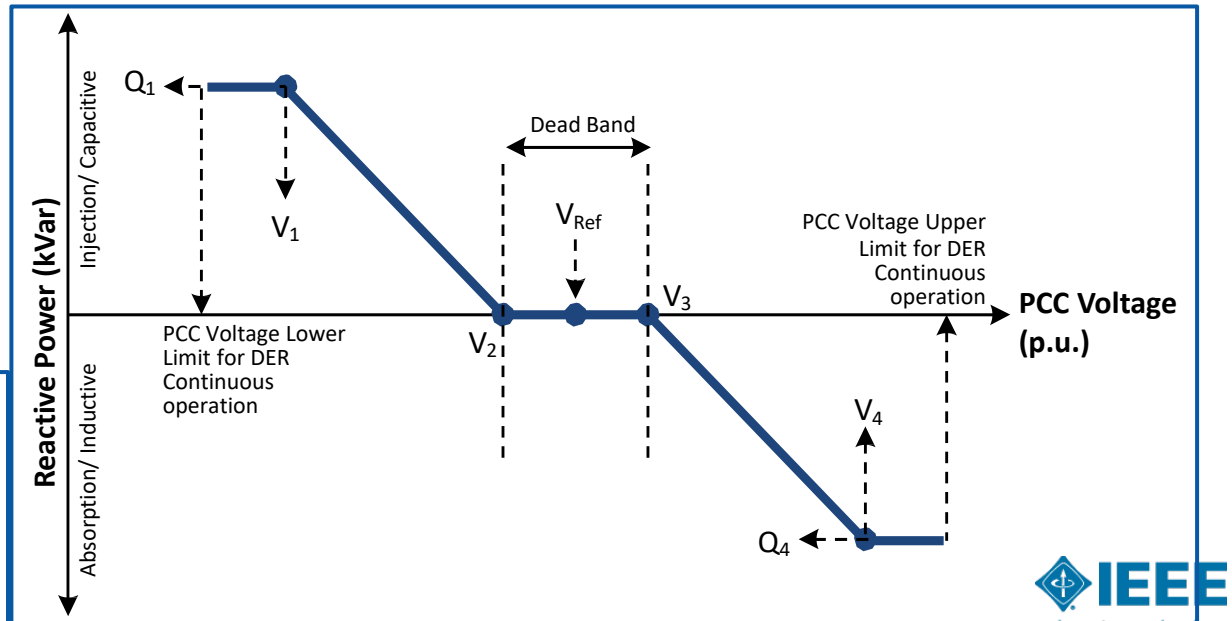
Draft P1547 WIP voltage regulation considerations underway

1. Reactive Power Capability of the DER

… capable of injecting and absorbing minimum reactive power …

2. Voltage and Reactive Power Control

… capabilities of modes of reactive power control functions:
Power factor; Volt-Var; Active-power power-factor; Reactive power

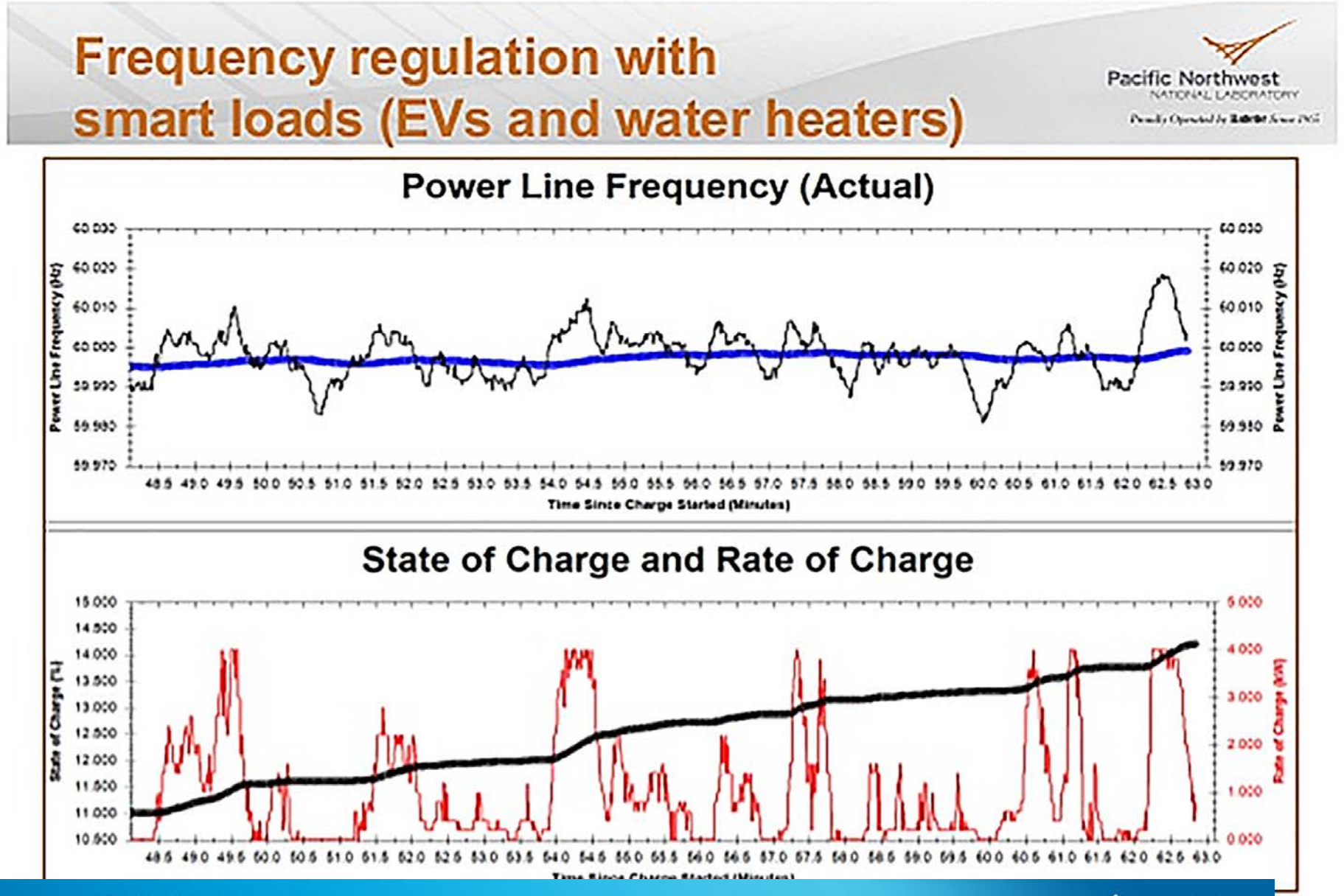


P1547/Draft 1
Figure - Volt-Var Mode

(not approved)

Example

- Increasing coordination (orchestration)
- Intelligent devices
- Autonomous and optimizing

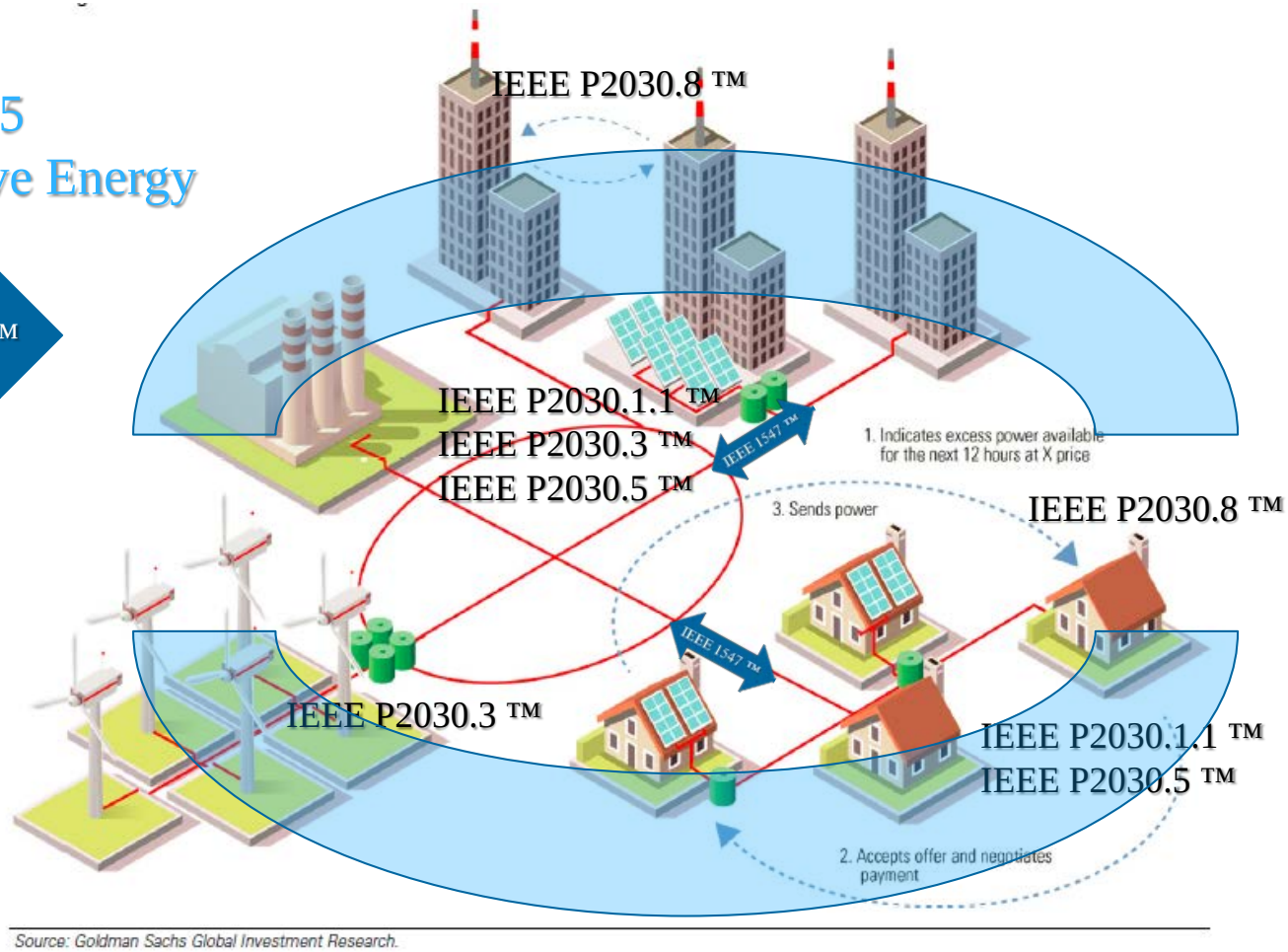


Slide Courtesy of DOE-PNNL

The End Zone: Transactive Energy Microgrid Network

IEEE P825
Transactive Energy
built on…

IEEE 1547 ™



Source: Goldman Sachs Global Investment Research.

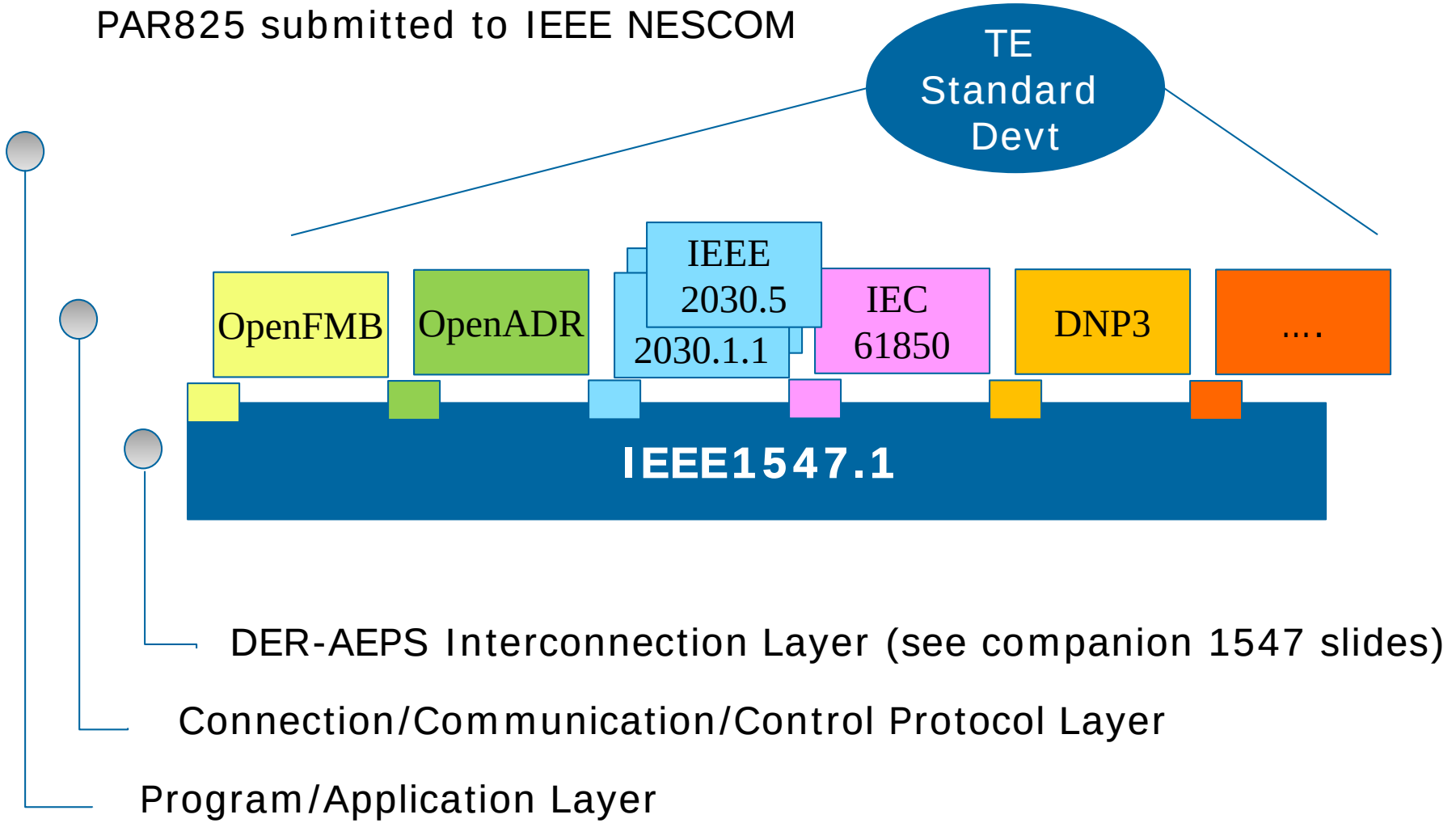
Combining blockchain with the Internet of Things could enable the negotiation of distributed power transactions. By using distributed wireless or wireline data links in a

IEEE 2030 Series Smart Grid Projects

- IEEE 2030 Series – Smart Grid Interoperability
  - **IEEE 2030™ Guide for Smart Grid Interoperability**
  - IEEE P2030.1™ **Guide** for Electric-Sourced Transportation Infrastructure
  - IEEE P2030.2™ **Guide** for Energy Storage Systems Integrated with the Electric Power Infrastructure
  - IEEE P2030.2.1 **Guide** for Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Applications Integrated with Electric Power Systems
  - IEEE P2030.3™ **Standard** for Test Procedures for Electric Energy Storage Equipment and Systems
  - IEEE P2030.4™ **Guide** for Control and Automation Installations Applied to the Electric Power Infrastructure
  - **IEEE 2030.5™ Standard for Smart Energy Profile 2.0 Application Protocol**
  - **IEEE P2030.6 ™ Guide for the Benefit Evaluation of Electric Power Grid Customer Demand Response**
  - **IEEE P2030.7 ™ Standard for the Specification of Microgrid Controllers**
  - IEEE P2030.100 ™ **Recommended Practice** for Implementing an IEC 61850 Based Substation Communications, Protection, Monitoring and Control System
  - IEEE P2030.101™ **Guide** for Designing a Time Synchronization System
  - IEEE P2030.102.1™ **Standard** for Interoperability of Internet Protocol Security (IPsec) Utilized within Utility Control Systems

Potential TE *Certification Program Basis*

Status: Nov 2016
PAR825 submitted to IEEE NESCOM



IEEE Conformity Assessment Program (ICAP)

Standards Conformance Solutions Enabling Market Implementation

ICAP

CERTIFICATION PROGRAMS

- Phasor Measurement Unit (PMU)
- Precision Time Protocol - Power Profile
- Precision Time Protocol – Telecommunications
- Ethernet Passive Optical Networks (EPON)
- Interconnection of Distributed Energy Resources (DER)
- Camera Phone Image Quality
- Nuclear Power Electrical Equipment

CERTIFICATION REGISTRY

INTERCONNECTION OF DISTRIBUTED ENERGY RESOURCES

With the accelerating adoption of Distributed Energy Resources (DER) and the growing interest in highly resilient microgrid configurations, there is increasing pressure on utilities to effectively, rapidly, and safely integrate these as clean and resilient energy resources into their Area Electric Power Systems. The IEEE 1547.1a™-2015 standard was initially published in 2003 and is increasingly viewed globally as the industry best practice for enabling grid interconnection to DERs. A formal ICAP program has been established by the IEEE Standards Association for governing the interconnection of DERs with the electric grid in accordance with this standard. The purpose of the program is to formalize the certification protocols that are needed to demonstrate conformance with the published IEEE 1547.1™ testing standard.

An IEEE 1547.1™ Conformity Assessment Steering Committee (CASC) was convened in 2015 with leading subject matter experts representing all stakeholders within the power industry. The purpose of this steering committee is to define, demonstrate and implement a common test protocol and certification process in order to broaden industry understanding and acceptance of IEEE 1547.1™. Utilities, regulators, service companies, and equipment manufacturers participating on this invitation-only committee are hoping to leverage these protocols to lower the

IEEE1547.1 CASCADE Activity Domains

Test Process	Business Process	Demo Program
• Standards Review • Commissioning Requirements Devt • Test Plan ***Templates*** • Develop Certification Repository • Online Tools • Automation/Harness • Conference – White Papers	• Economic Modeling • Regulatory Outreach • Legislative Outreach • Academic Program Integration • Conference – White Papers	• Create CASCADE Demo Partnership(s) • Design Local Demo Program(s) • Develop Test Plan(s) from ***Template*** • Manage growing Demo Portfolio • Compile learnings into Best Practices

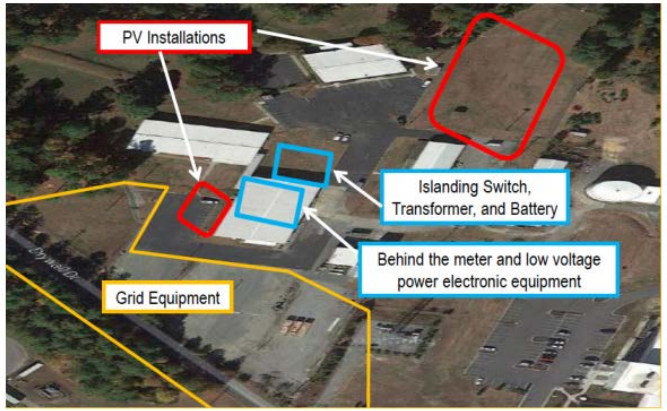
IEEE 1547.1 CASCADE Pilot: Raleigh NC

"Agile Conformity Testing – Rapid Scaling"

ABB FREEDM systemscenter DUKE ENERGY.

Phase 1a

Phase 1b



Duke's long-range hopes for this grand experiment in multi-vendor interoperability are twofold, he said. "The first goal is to promote interoperability between devices. The second is for Duke to find out if we can potentially offer microgrid services in the future."

Thank You!

IEEE Standards Association
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Bill leads all of the Smart Grid related standards development initiatives

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Paul supports the IEEE1547 CASCADE and P825 Interoperability programs

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Ravi leads the Conformity Assessment certification process for applicable IEEE standards