DER Management & Implementation Use Cases

We Can Control DERs, Now What?

Presented for ESIG (Sept 30, 2024)

By: Cody Davis, Senior Principal Engineer, Electric Power Engineers

Types of Distirbuted Energy Resources (DER)

Solar Photovoltaic Systems

Wind Turbines

Energy Storage Systems

Combined Heat and Power

Electrical Vehicles

Managed or Price-Based Charging

Grid Interactive Buildings

Building equipped with smart appliances and energy management systems to contribute in EE and DR programs

Energy Efficiency

Microturbines

Localized generation using natural gas

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Approach Today: Start from "Ideal" DER then adapt for specific technologies

IEEE 1547 - 2018

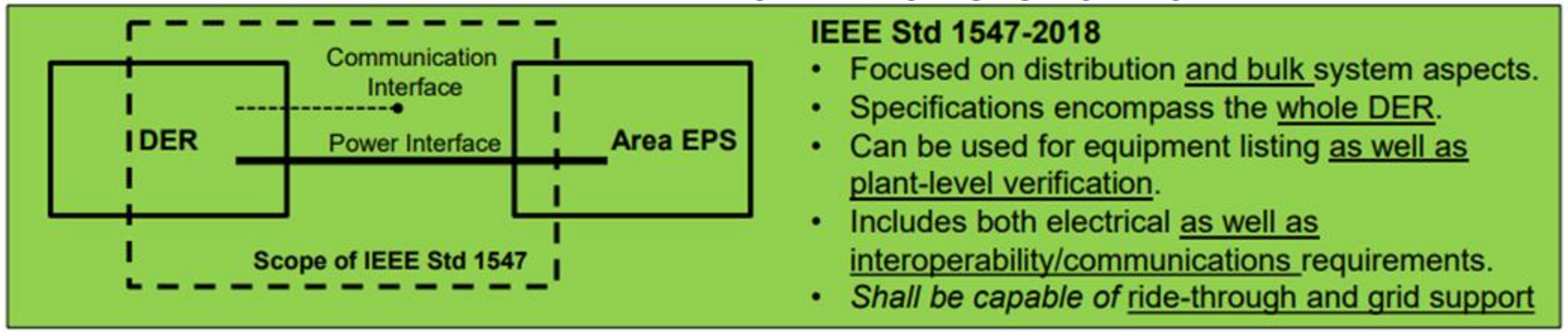
Standard for DER Integration Within Distribution Systems

IEEE 1547-2018 Overview

DER Integration Standard

- Standard governs definitions, inverter requirements, interoperability
  - Requires Smart Inverter function capabilities
- Roles for Manufacturers, Utilities, ISO/RTO, Commissions, and Customers/Installers
- Compliant hardware certified to UL 1741-SB
  - Prior to 2024, hardware certified using UL 1741 SA based on 1547a-2014

IEEE 1547-2018 Overview



Ride-Through Curves

Bulk Power System Reliability Support

- **Inverter must remain connected and generating for some system disturbances to prevent large-scale simultaneous tripping**
  - Voltage Ride-Through (High and Low)
  - Frequency Ride-Through (High and Low)
  - Default enabled for 1547-2018 compliance
  - Often based on ISO/RTO recommendations
- **Operating Modes:**
  - Continuous Operation: “Do your thing”
  - Mandatory Operation: Thou shalt not trip until allowed
  - Momentary Cessation: Stop operating but don’t shut down, “be ready for round 2”

Table 5: Low/High Voltage Ride Through (L/HVRT) minimum requirement – ACTIVATED

Region	Voltage range (% of nominal voltage)	Operating Mode/Response	Min. ride-through time (s)	Max. Trip Time (s)
HIGH VOLTAGE 2 (HV2)	V ≥ 120	Cease to Energize	N/A	0.16
HIGH VOLTAGE 1 (HV1)	110 < V < 120	Momentary Cessation	12	13
NEAR NOMINAL VOLTAGE (NN)	88 ≤ V ≤ 110	Continuous Operation	Infinite	N/A
LOW VOLTAGE 1 (LV1)	70 ≤ V < 88	Mandatory Operation	20	21
LOW VOLTAGE 2 (LV2)	50 ≤ V < 70	Mandatory Operation	10	11
LOW VOLTAGE 3 (LV3)	V < 50	Momentary Cessation	1	1.5

Table 6: Low/High Frequency Ride Through (L/HFRT) minimum requirement – ACTIVATED

Region	System Frequency Default Settings	Minimum Range of Adjustability	Ride-Through Until	Ride-Through Operational Mode	Maximum Trip Time
HIGH FREQ 2 (HF2)	f > 62	62.0 – 64.0 Hz	No Ride-Through	NA	0.16s
HIGH FREQ 1 (HF1)	60.5 < f ≤ 62	60.1 – 62.0 Hz	299	Man. Operation	300s
NEAR NOMINAL (NN)	58.5 ≤ f ≤ 60.5	NA	Indefinite	Con. Operation	NA
LOW FREQ 1 (LF1)	57.0 ≤ f ≤ 58.5	57.0 – 59.9 Hz	299	Man. Operation	300s
LOW FREQ 2 (LF2)	f < 57.0	53.0 – 57.0 Hz	No Ride-Through	NA	0.16s

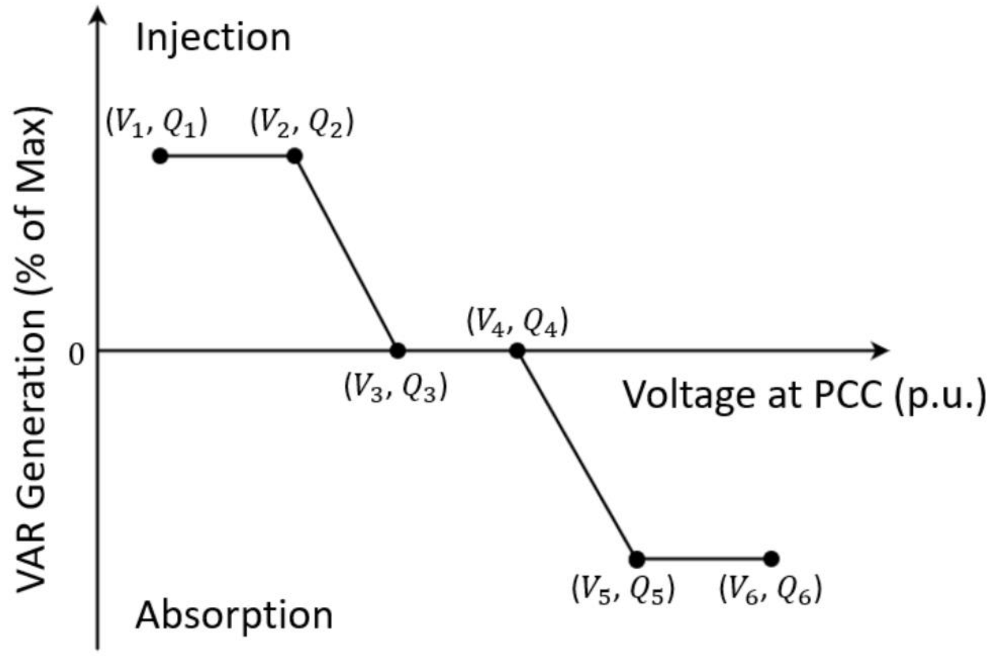
Source: IEEE 1547-2018 Standard

Autonomous Voltage Support

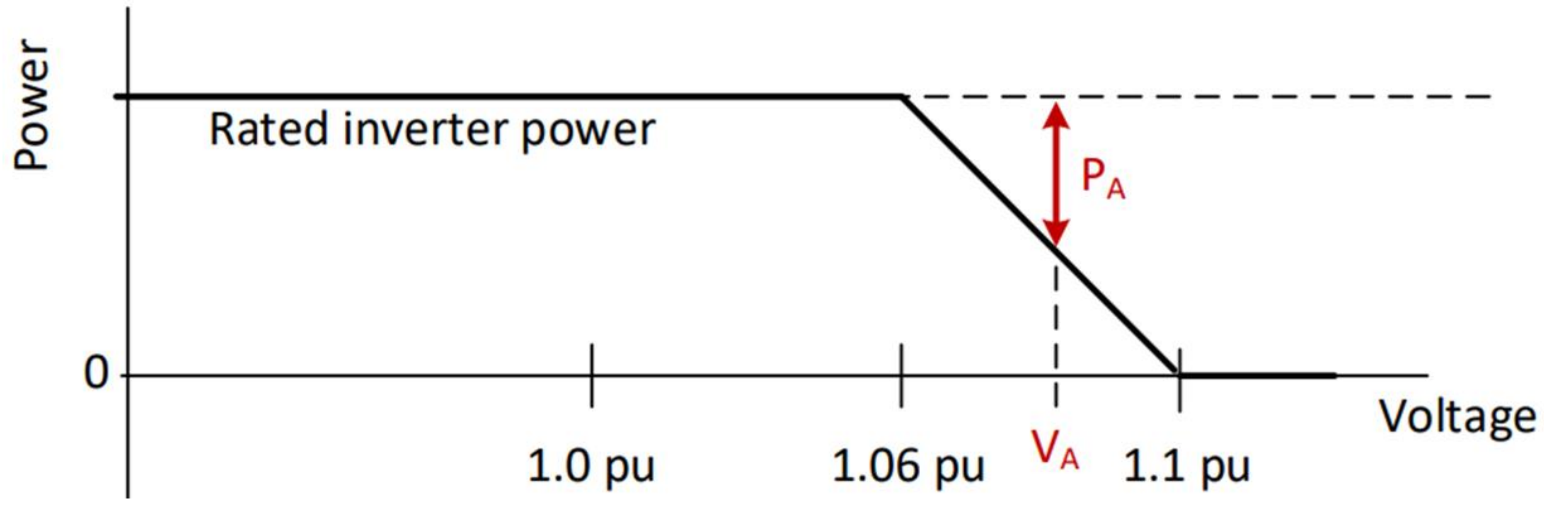
Volt/Var and Volt/Watt Functions

- Volt/Var Curve: Measure the voltage and respond by changing the amount of reactive power supplied
  - Dead-Band: No reactive support needed
  - As voltage increases -> Absorb reactive power
  - As voltage decreases -> Inject reactive power
- Volt/Watt Curve: Measure the voltage and respond by changing the amount of real power generated
  - Can be used in addition to Volt/Var to address overvoltage
- Autonomous functions are very effective at addressing local voltage violations that the DER can measure
- Curve points can be customized, vary by state/utility

Volt/Var Curve:



Volt/Watt Curve:



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Communications Capabilities

- Local Communication Interface required to be available under 1547-2018
- **Communication Protocols:**
  - Sunspec Modbus
    - Serial – Modbus RTU
    - Ethernet – Modbus TCP
  - IEEE 2030.5
    - Ethernet, VPN Structure
  - DNP3
    - Not commonly used by distribution inverters
- Other potential data sharing and communication pathways may be available (e.g., aggregator)
- Pilot Program – PPL (Pennsylvania)

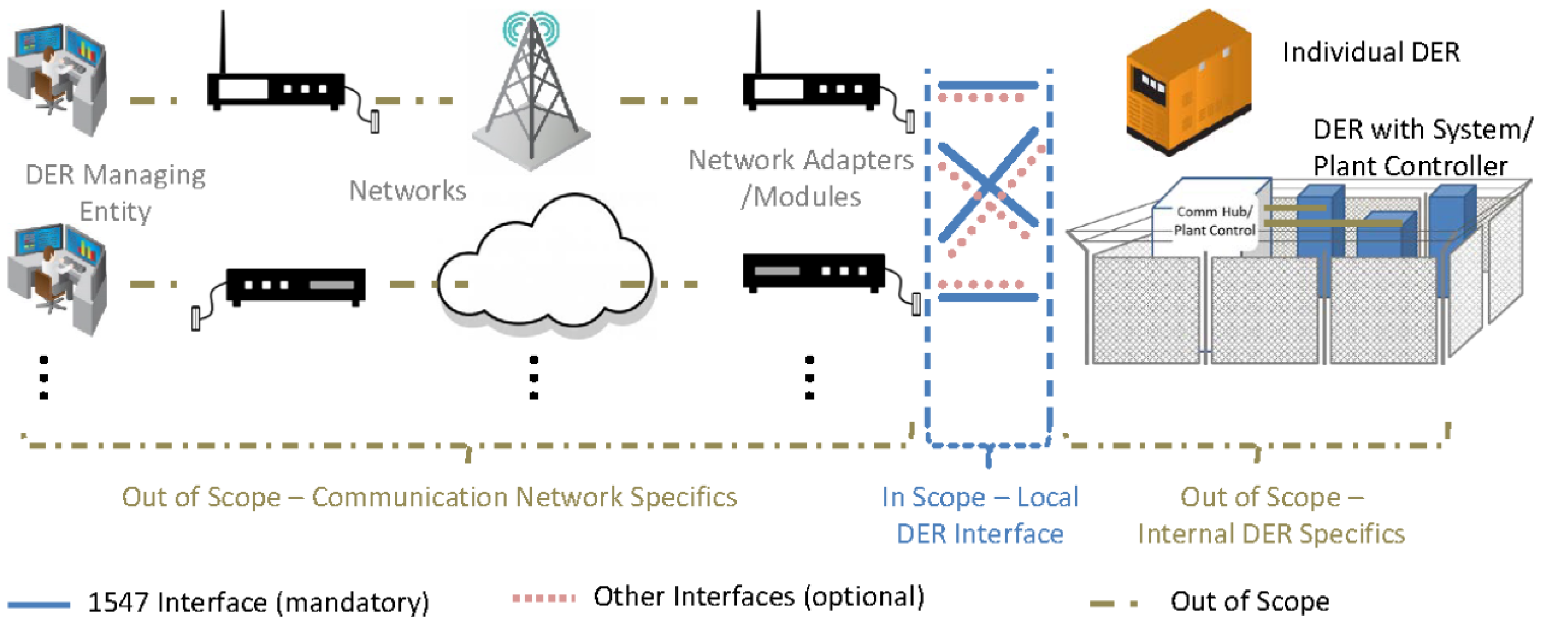

Table 41—List of eligible protocols

Protocol	Transport	Physical layer
IEEE Std 2030.5 (SEP2)	TCP/IP	Ethernet
IEEE Std 1815 (DNP3)	TCP/IP	Ethernet
SunSpec Modbus	TCP/IP	Ethernet
	N/A	RS-485

Source: 1547-2018 Standard Section 10.7

So we can communicate with DER....

What can we do with it that is useful?

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We Can Get New Data

DER Monitoring

Read, monitor, and build historical data for:

- **DER Performance and Local Conditions**
  - Measured Voltage
  - DER Amps
  - **DER Real Power magnitude**
  - DER Reactive Power magnitude
  - DER Power Factor
  - On/Off Enablement
- **Smart Inverter Setpoints**
  - Volt/Var Curve Points
  - Volt/Watt Curve Points
  - Ride-Through Points
- **DER Status and Other Parameters**
  - Control Mode
  - Other Parameters

Improve Modeling and Forecasting
Calculate Volt/Var & Volt/Watt Curtailment
"Hidden Load" Detection
Unintentional Island Detection

Verify Settings (e.g., Customer Commissioning)

Status Awareness

We Can Modify DER Performance

DER Management

Write new values and modify DER performance by:

- **Programming new smart inverter settings** → Tailor Volt/Var for Local Optimization; Respond to System Changes
- **Setting Reactive power level** → Respond to Non-Local Voltage Violations
  - **Power Factor Setpoint**
  - **Reactive Power Setpoint**
- **Disabling or Enabling production** → Respond to Unintentional Islands (Safety)
- **Setting maximum real power level** → Flexible Interconnection; Contingency Response Improvement

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DER Management Use Cases – DER Monitoring

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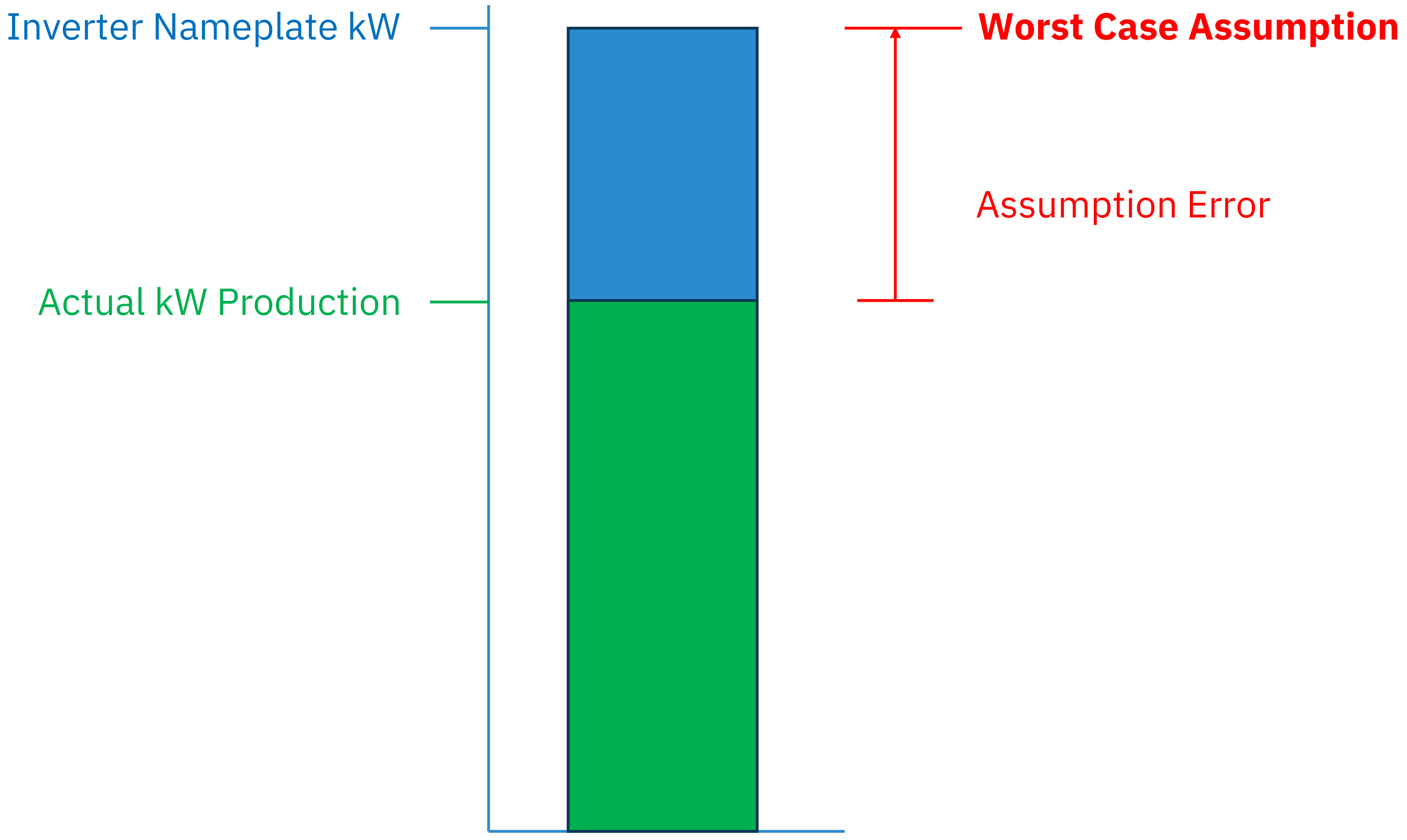
DER Real Power Data Uses

Planning and Operational Uses

- In the absence of actual data, **assumptions** about DER performance are used for analyses and operations
    - Common “Worst Case”: **Nameplate kW**
- Using **real data** increases the **accuracy** of models and resulting studies
    - Planning Models and Studies
        - Interconnection Studies
        - Hosting Capacity
        - Capacity and Voltage Drop
    - Operational Models
        - ADMS Power Flow and State Estimation

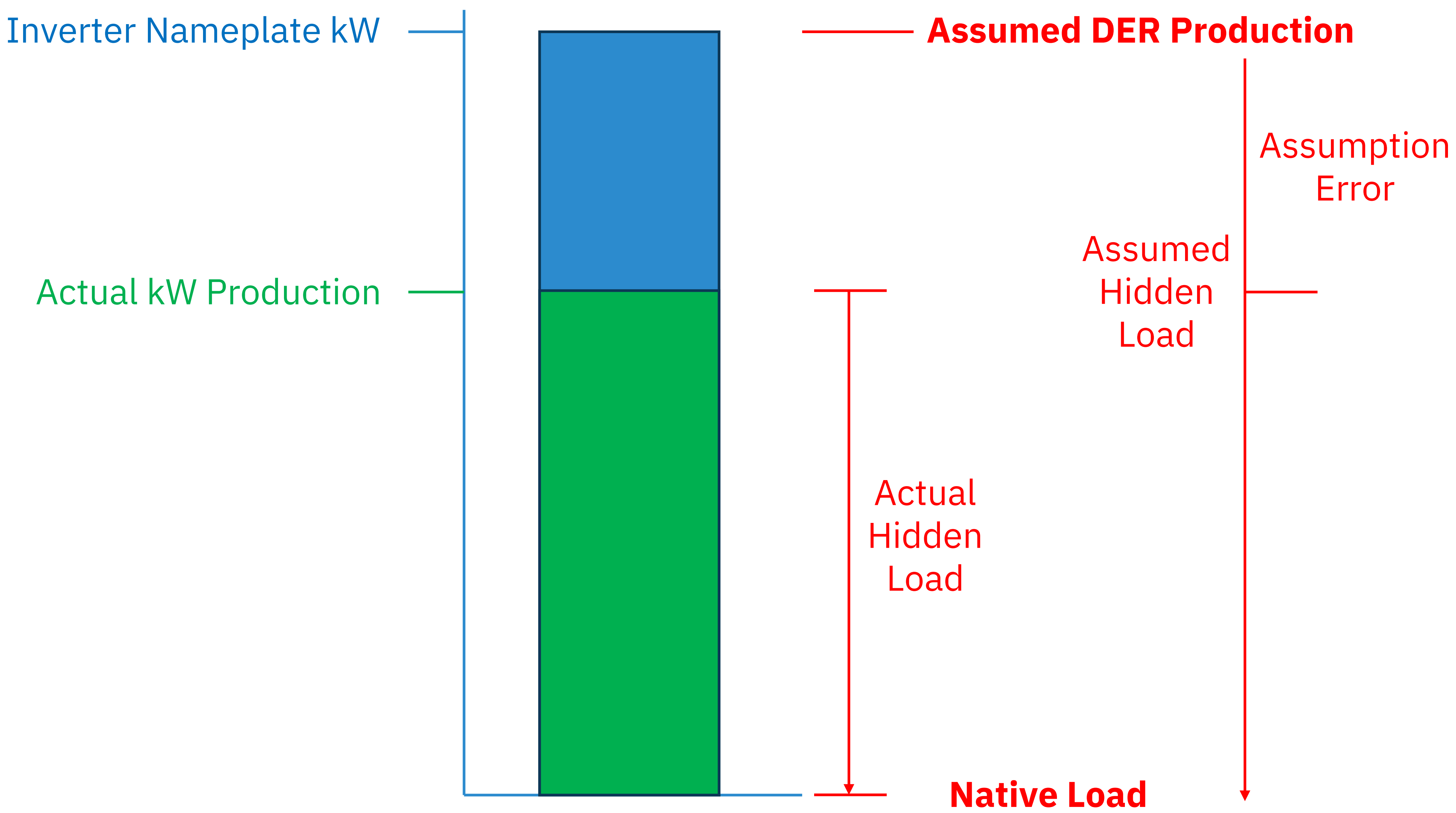


DER Production Variation
And Relevant Assumptions

Capacity Planning Impact

De-Mystifying "Hidden" Load

- Capacity planning generally focuses on **peak load** when capacity is most constrained
- DER have added a new dimension to capacity planning: "Gross": Vs "Net" Load
  - "Net" Load: **Measured** peak load passing through distribution infrastructure
  - "Gross" or Native" Load: **Total** peak load served by either distribution infrastructure or embedded DER
  - "Hidden" or "Masked" Load: Portion of peak load **sourced from DER**
  - **Gross Load = Net Load + Hidden Load**
- Using **accurate data** decreases assumed hidden load, **increases capacity**, **reduces investment needs**



DER Production Variation
And Relevant Assumptions

DER Management Use Cases – Smart Inverter Settings Modification

Managing Smart Inverter Settings

Differences from Existing Strategies

- Current Volt/Var Curve(VVC) Practices:
  - System or State-wide Curves
  - “Do No Harm” Approach
  - “Set it and Forget it”
- Improvements from Management:
  - Be more aggressive at using VVCs to address issues
  - Change VVCs for customers with high curtailment
  - Adjust VVCs or Ride-Throughs following system changes

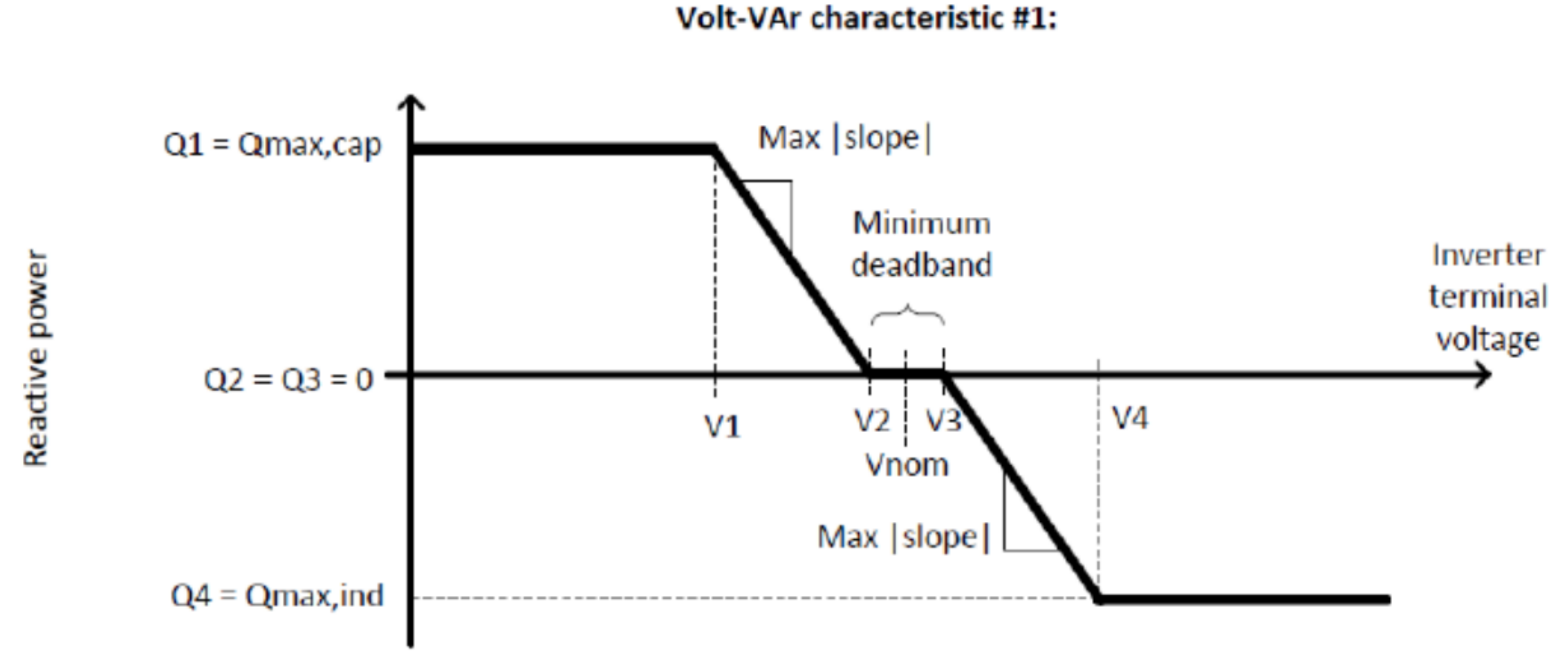
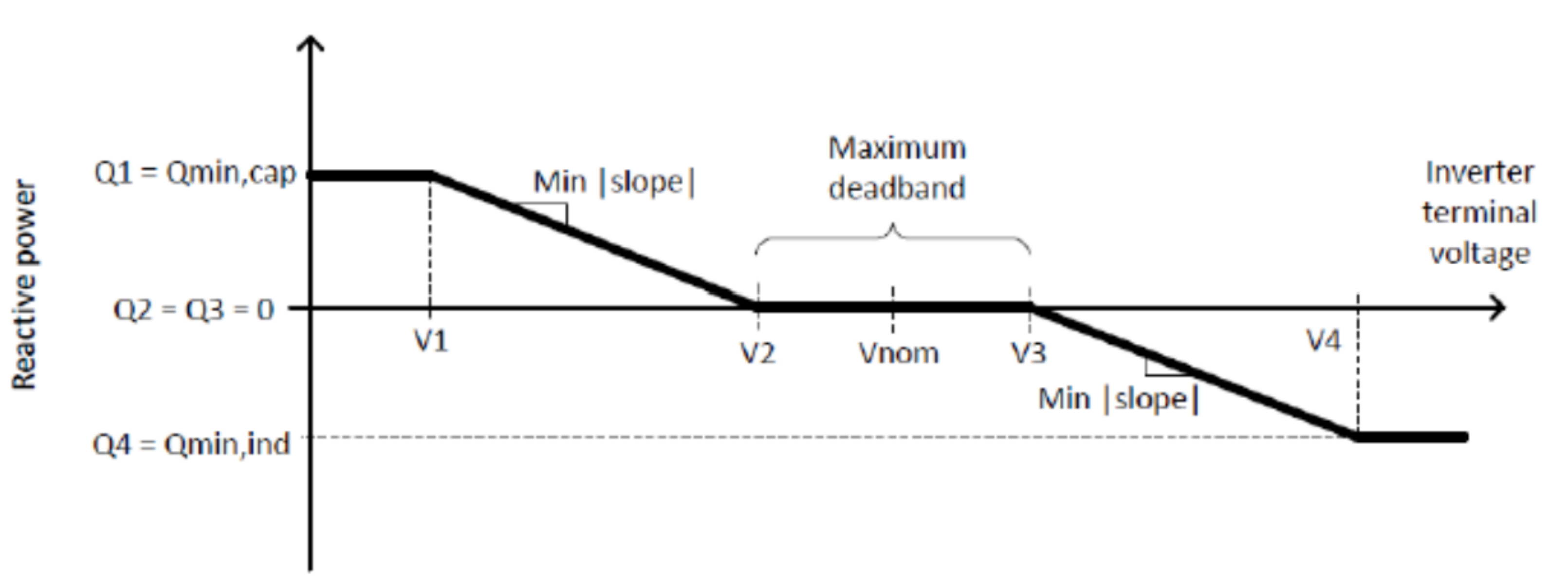


Figure 11: “Most Aggressive” Volt-VAR curve for R21-1-VV11, Test 1.



“Aggressive” vs “Less Aggressive” VVC Examples

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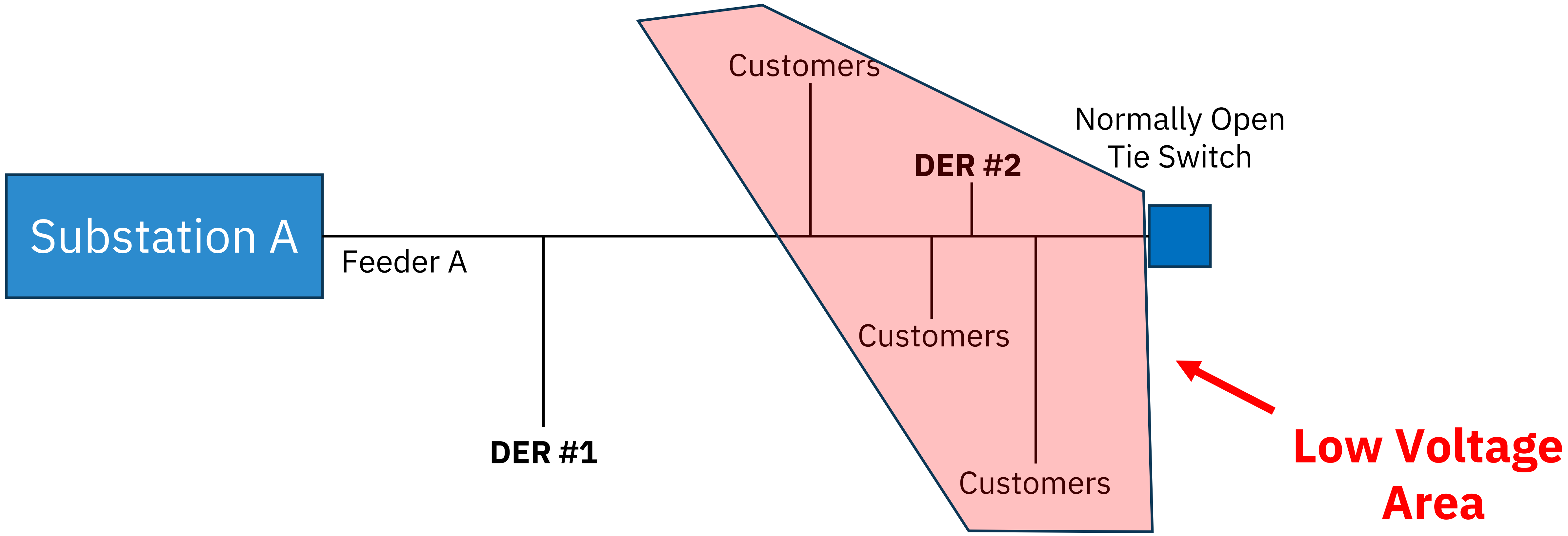
Source: Sunspec Alliance / USCD Smart Inverter Performance Testing (https://sunspec.org/wp-content/uploads/2019/08/2.2EPC-14-036SmartInverterEvaluationReport.pdf)

DER Management Use Cases – Reactive Power Management

Reactive Power Management

Voltage Support - Expanded

- Volt/Var and Volt/Watt functions respond to **voltage violations they measure**
  - Limited support for voltage issues in other locations
    - Volt/Var curve on DER #2 will max out reactive power support autonomously
    - Volt/Var curve on DER #1 still responds to its local voltage, may not support voltage violation at all (deadband)
  - Reactive Power management enables the centralized control system (e.g., ADMS/DERMS) to change the power factor of DER #1 to help respond to voltage issues in other areas

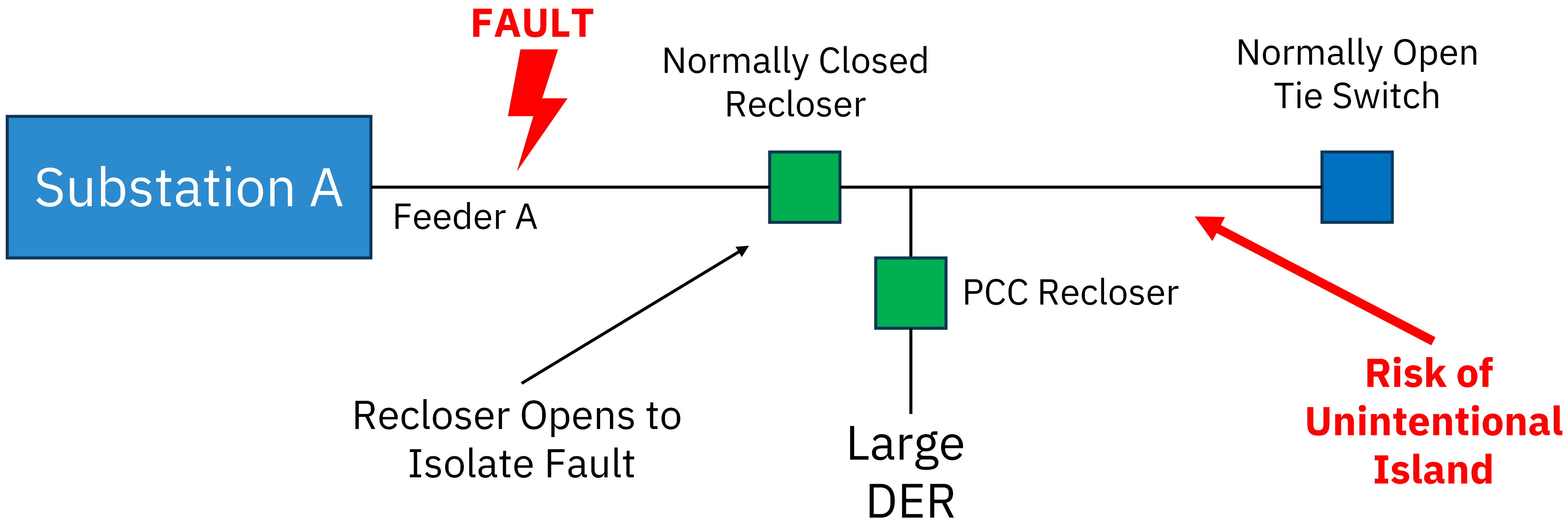


DER Management Use Cases – Real Power Management

Unintentional Islanding Response

Safety Considerations

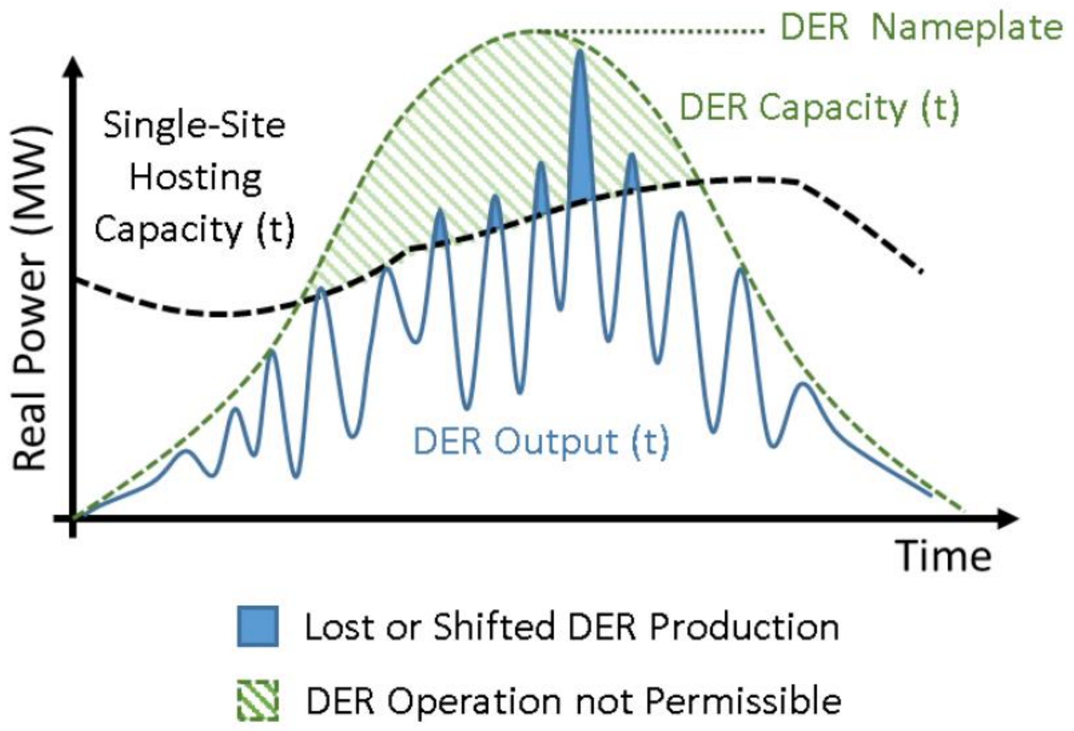
- **Unintentional Island:** Unexpected continued energization of distribution and/or customer equipment after loss of source
- DER Required to detect islanding and cease energization within 2 seconds
- Potential risk of detection failure and island run-on, especially if DER matches load (real and reactive)
- Management allows for detection and remote DER cessation during unintentional island



Flexible Interconnection

Traditional Interconnection: Static
- All Studies Based on Nameplate Size
- Constant Power Factor or Volt/Var
- No Visibility or Control

Flexible Interconnection: Dynamic
- Studies Based on **Controlled Output**
- Operational / Historical Data Available
- Volt/Var Function Enabled
- **Real and Reactive Power Override**



Benefits
- Lower Interconnection Costs
- Faster Interconnection Times
- Increased Infrastructure Utilization

Visual Source: EPRI – Understanding Flexible Interconnection (https://www.epri.com/research/products/000000003002014475)

Sample Study Results – 2 MW Solar

Month	Estimated Curtailment (MWh)	Estimated Percent of Gen Curtailed	Estimated Hours Curtailed
January	0.00	0.00%	0
February	0.00	0.00%	0
March	0.63	0.07%	8
April	1.80	0.18%	14
May	1.01	0.10%	11
June	0.00	0.00%	0
July	0.00	0.00%	0
August	0.00	0.00%	0
September	0.00	0.00%	0
October	0.00	0.00%	0
November	0.00	0.00%	0
December	0.00	0.00%	0
Annual:	**3.44**	**0.04%**	**33**

Curtailment (MWh)					Weekday Graph							
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
12:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8:00 AM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9:00 AM	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10:00 AM	0.00	0.00	0.00	0.13	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11:00 AM	0.00	0.00	0.00	0.20	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12:00 PM	0.00	0.00	0.00	0.20	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1:00 PM	0.00	0.00	0.10	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:00 PM	0.00	0.00	0.30	0.39	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00 PM	0.00	0.00	0.19	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11:00 PM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Flexible Interconnection

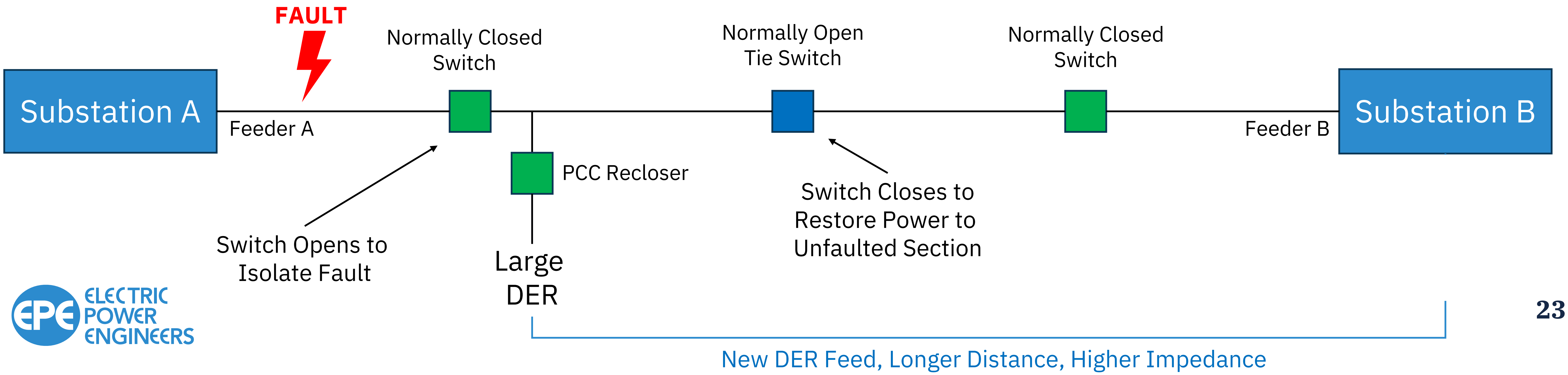
Challenges

- Requires **fundamental changes** to interconnection study approach, process, and results
- Flexible Interconnection Studies are significantly more **complex** and **time-consuming** to perform today
- **Multiple curtailment strategies** with **different pros and cons** – Last In, First Out Vs Pro-Rata (Proportional) Vs Others
- Who **bears the risk** if curtailment estimates aren't accurate or the system changes?
- Difficult to Assess **long-term** curtailment and financial impacts on DER customers.

Contingency Operations Improvement

Compared to Existing Practices

- During outage response, some areas may be switched to an **alternate source** to restore power while repairs are being made
- DER may cause issues in the new configuration (more distance & impedance)
  - Existing Practice: **Disable DER production** (e.g., Open PCC recloser)
  - With DER Management: **Adjust Maximum Output** to prevent issues



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What can we do with DER Monitoring and Management?

Improve outcomes for both DER and non-DER customers

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Q&A

Monday, September 30, 2024 3:00 PM - 4:00 PM

(UTC-05:00) Central Time (US & Canada)

Host

ESIG Account

Agenda

Featured Speaker: Cody Davis, Senior Principal Engineer, Distribution & Grid Modernization, Electric Power Engineers

Webinar Abstract: Recent changes to inverter interoperability capabilities for IEEE 1547-2018 and UL 1741 SB compliance have further reduced barriers to utilities communicating with and controlling DER. Utilizing such features to gather actual data on DER system performance and modify DER real and reactive power performance in response to changing grid conditions can provide significant value to both utilities and DER owners. Understanding how these capabilities can be utilized to improve distribution planning and operational outcomes is critical to developing a strategy for DER Management and developing a business case for DER Management System (DERMS) deployment. This presentation will identify the value drivers and utility process improvements that can be achieved using the DER communications and control capabilities to support the distribution system.

Target: 45 Mins

- Intro and DER Types (2 Mins)
- Interconnection Standard 1547-2018 (6 Mins)
- DER Communications and Management (5 Mins)
- Use Cases – Data Monitoring (5 Mins)
- Use Cases – Modifying SI Settings (3 Mins)
- Use Cases – Control Reactive Power (5 Mins)
- Use Cases – Control Active Power (15 Mins)

The schedule for the webinar is one hour, with a 5 min intro by ESIG, 40-45 min presentation, and 10-15 min Q&A