Overcoming Challenges for DER Interconnection – Spotlight on Energy Storage

Distributed Generation Integration Collaborative Workshop

July 29, 2019
Washington, D.C.

NREL/PR-7A40-74959

Document Overview

- On July 29, 2019, the Distributed Generation Integration Collaborative (DGIC) convened a half-day interactive workshop in Washington, D.C.
- Organized by the Electric Power Research Institute (EPRI) and the National Renewable Energy Laboratory (NREL), the workshop explored a variety of issues related to the grid interconnection of energy storage and solar-plus-storage systems, primarily on distribution networks.
- Core workshop objectives included:
  - Identifying existing utility, developer, Authority Having Jurisdiction (AHJ), and end-user challenges to interconnecting energy storage
  - Identifying gaps in knowledge, strategies, and considerations for supporting greater grid integration of distributed energy storage, especially in ways that better leverage the multiple services (i.e., the "value stack") offered by the distributed devices.
- This document provides the workshop's proceedings as well as stakeholder perspectives—documented during a workshop breakout exercise—on a range of industry actions that can be undertaken to improve energy storage interconnection.
  - The latter stakeholder identified actions are intended to help guide research, regulatory, and broader industry development efforts.
  - These actions wholly represent the perspectives and opinions of the workshop participants; EPRI, NREL, and DOE neither endorse nor oppose the suggested actions.

Table of Contents

Introduction to DGIC and Workshop Overview

Distributed Generation Integration Collaborative (DGIC)

- Supported by U.S. Department of Energy (DOE) SunShot Initiative, formed in October 2013
- Focused on informational exchange and innovation related to distributed photovoltaic (PV) interconnection processes and practices
- EPRI leading DGIC starting in 2019

Distributed Generation Integration Collaborative

https://www.nrel.gov/dgic/

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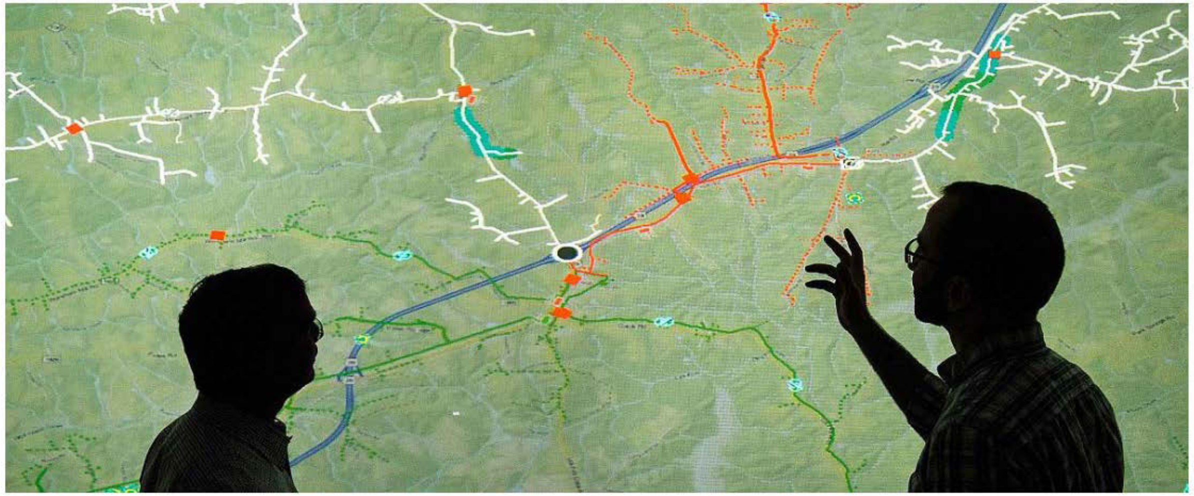


The Distributed Generation Integration Collaborative (DGIC) brings together utilities, industry participants, and other stakeholders to exchange best practices and lessons learned for grid integration of distributed energy resources (DERs).

EPRI ELECTRIC POWER RESEARCH INSTITUTE

DGIC Research Topics

- Research
  - Interconnection
  - Business Models & Regulation
  - Technologies & Mitigation Methods

Distributed Generation Integration Collaborative Research

The Distributed Generation Integration Collaborative provides a forum for the exchange of information on the most pressing topics in distributed energy resource (DER) integration.

Click on each of the linked topics below to find useful publications, webinars, blog posts, and other resources.

Interconnection Standards, Application Management, and Technical Screening

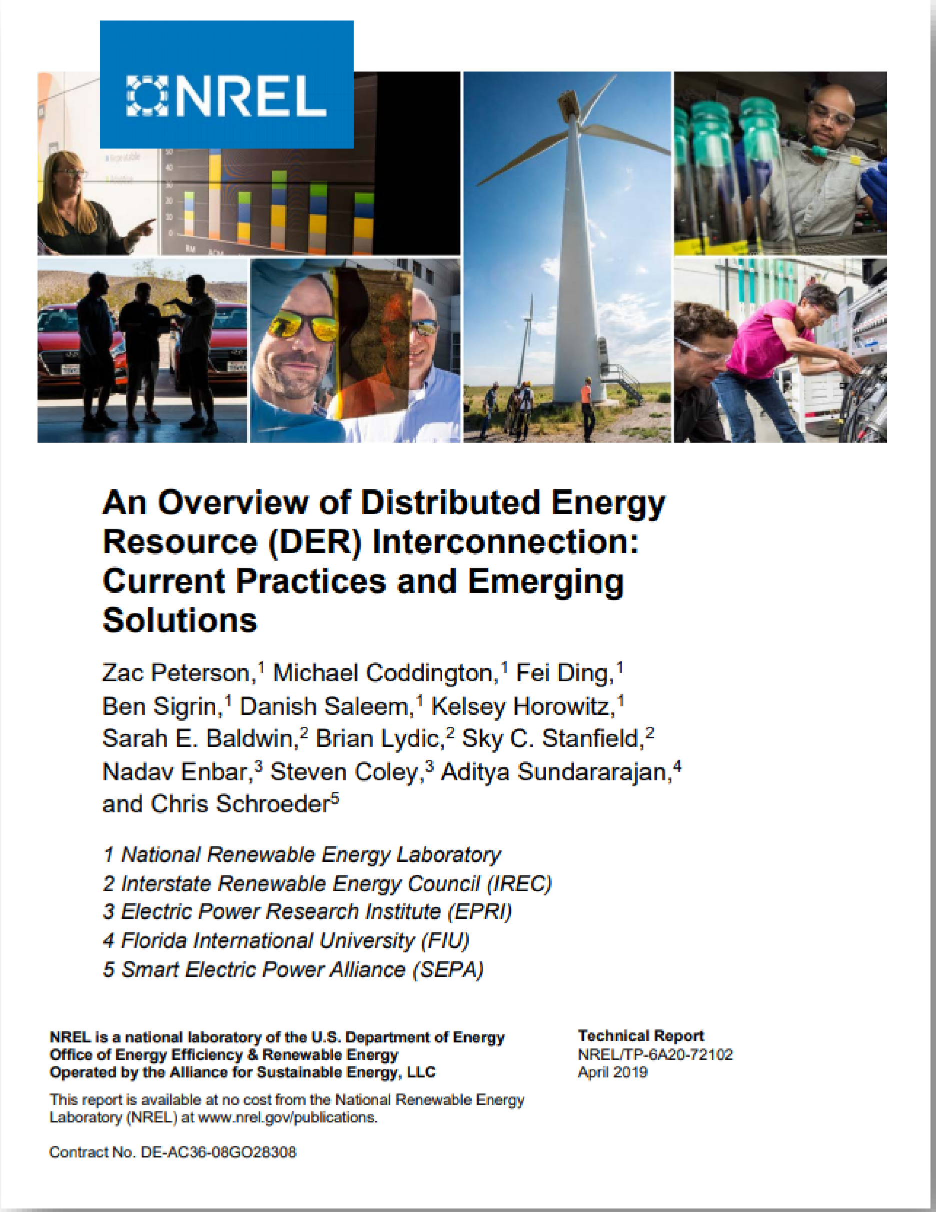
The growth of DERs, expanding technologies (e.g., smart inverters), and evolving standards are driving improvements to interconnection practices and procedures. These changes encompass application management and processing, technical review, staffing, and infrastructure.

Business Models, Economics, and Regulatory Considerations

Increasing DER penetrations are fostering new business models, raising new regulatory considerations, and driving economic reassessment of novel DER integration strategies.

Technologies and Methods for Mitigating DER Impacts

Adoption forecasting and new technologies—including advanced inverters and distributed energy resource management systems—are supporting the wider adoption of DERs on the grid.



NREL

An Overview of Distributed Energy Resource (DER) Interconnection: Current Practices and Emerging Solutions

Zac Peterson,[1] Michael Coddington,[1] Fei Ding,[1] Ben Sigrin,[1] Danish Saleem,[1] Kelsey Horowitz,[1] Sarah E. Baldwin,[2] Brian Lydic,[2] Sky C. Stanfield,[2] Nadav Enbar,[3] Steven Coley,[3] Aditya Sundararajan,[4] and Chris Schroeder[5]

1 National Renewable Energy Laboratory
2 Interstate Renewable Energy Council (IREC)
3 Electric Power Research Institute (EPRI)
4 Florida International University (FIU)
5 Smart Electric Power Alliance (SEPA)

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Technical Report
NREL/TP-6A20-72102
April 2019

Workshop Overview

Summary

- Interactive discussion of considerations for interconnecting energy storage and identification of high priority actions for overcoming existing challenges

Attendees

- 55 participants, including utilities, regulators, developers, consultants, and industry associations

Content

- Subject matter expert presentations on field experiences and ongoing standards development
- Small-group breakout exercise to identify and prioritize stakeholders actions to advance the interconnection of energy storage and its integration with other distributed energy resources (DERs), such as solar PV

Workshop Agenda

MONDAY, JULY 29, 2019	
TIME	**TOPIC**
1:00 p.m.	**Introduction & Welcome** *Introduction to the DGIC, workshops objectives, agenda, and format*
1:15 p.m.	**Energy Storage Interconnection Challenges: Field Experiences & Case Studies** *Real-world perspectives on a range of issues that are slowing the proliferation of energy storage deployment, as well as potentials solutions*
2:15 p.m.	**Break**
2:30 p.m.	**Standards/Certifications & Market Rules Developments** *Review of standards and rulemaking activities and their intended effect energy storage interconnection challenges*
3:15 p.m.	**Breakout Exercise** *Stakeholder identification and prioritization of near- and mid-term actions that utilities and supporting organizations (e.g., national labs, industry associations, regulators and policymakers, etc.) can undertake to improve the interconnection of energy storage and its integration with other DERs, such as PV*
4:15 p.m.	**Closing Remarks & Next Steps**
4:30 p.m.	**Adjourn**

Breakout Exercise Results

Breakout Exercise Overview

Process:

1. Participants brainstormed actions to improve energy storage interconnection
2. Participants shared actions in small groups to further discuss them and identify the actions' priority level and timeline
3. Participants reconvened and reported out to large group

Objectives:

Identify actions needed to improve energy storage interconnection

↓

Prioritize actions and associated timeframe

↓

Identify highest priority, near-term actions and relevant stakeholders

Breakout Exercise Outputs

- Participants brainstormed 130+ raw ideas and actions, and assigned each a priority level (low, medium, high) and timeframe (1-2 yrs., 3-5 yrs., >5+ yrs.).
  - The majority of ideas were assigned high priority and a 1-2 year timeframe.
- DGIC workshop organizers collected and reviewed stakeholder input.
- Where necessary/appropriate, actions were clarified or pared down and organized into seven categories representing overarching thematic challenges to energy storage interconnection.
- Raw input was synthesized into 70+ actions across the seven categories.

Note: The documented actions wholly represent the perspectives and opinions of the workshop participants; EPRI, NREL, and DOE neither endorse nor oppose the suggested actions.

Moving from Brainstorming to Action

- Documented results are intended to identify industry pathways to solutions that can enable more streamlined and effective energy storage interconnection.
- Workshop attendees and broader industry participants are encouraged to build on the list of actions, identify supporting partnerships, and engage in collaboration to address identified needs.
- The results represent perspectives and opinions of the individual workshop participants, rather than an industry consensus document developed through comprehensive analysis.
  - Additional actions may be needed/appropriate, and/or recorded actions may require refinement.

Challenge Categories & Definitions

Challenge	Definition / Solution
Data & Communications	1. Determination of the data required to interconnect energy storage as well as data maintenance needs/requirements for utility management 2. Approach(es) for enabling IEEE 1547-compliant communication, monitoring, and control of DERs by electric utility/3rd-party aggregator
Economics, Market Design, and Regulatory Barriers	Creation and definition of market rules, regulatory reforms, and associated methodologies that convey the costs and benefits of grid-connected energy storage
Education	Education and training in the form of white papers and reports, webcasts, in-person meetings, and seminars that are intended for a variety of stakeholders—including regulators, utility staff, installers, developers, government officials, and other stakeholders—and to cover a range of foundational and "hot" topics relevant to energy storage interconnection and operation
Hosting Capacity Analysis	Coherence in the way energy storage should be technically considered and modeled when evaluating the level of grid hosting capacity needed to accommodate interconnection (e.g., load vs. sink, need for mitigation, etc.)
Protection & Transformer Issues	1. Best practice approaches for cost effectively and efficiently ensuring grid reliability and safety alongside the interconnection of energy storage (e.g., use of DTT and protective relays for fault current protection, on-board inverter anti-islanding capability, revision to remedial action schemes [RAS], short circuit ratio, etc.) 2. Industry consensus on distribution transformer design requirements to accommodate energy storage interconnection issues, including those relevant to two-way power flows (e.g., grounding, fault current and protection, efficiency losses and/or degradation when accommodating high frequency noise from inverters)
Standards & Utility Procedural Reform	Development and updating/revision of statewide interconnection standards; federal standards and guidelines (IEEE), certifications (UL) and codes (NFPA, NEC, etc.); and utility procedures (TIRs) that dictate energy storage interconnection requirements
Tariff Compliance & Metering	Clarity and consistency in the manner by which: 1. Energy storage devices and control methods can comply with the functional requirements of relevant tariffs, while providing multiple services (i.e., the value stack); and 2. Metering methodologies/arrangements for inverter-based devices under two-way flow situations can be employed, particularly when a customer is interconnecting multiple devices behind the meter (and must therefore comply with local tariffs).

Note: The categories and their definitions are intended to help organize the actions voiced at the workshop in an effort to make them more accessible. However, the scheme is imperfect and some actions may fall into multiple categories.

Challenge: Data & Communications

Suggested Action(s): 1-2 years – High Priority

- Establish real-time communication between DERs and the electric utility based on a meaningful SCADA/DERMs standard or operational minimum requirement. *(Note: hardware capabilities already exist, as laid out by IEEE 2030.5).*
- Determine what data is needed from energy storage to support interconnection (e.g., data that should be included in GIS to accurately convey system dynamics).
- Define the accuracy requirement for DERs to provide "production data" (kW, kVar, V) status.

Suggested Action(s): 3-5 years – High Priority

- Consider options for funding the cost of communications infrastructure (e.g., socialize in the rate base, public/private partnership, etc.).

Suggested Action(s): >5 years – High Priority

- Create a DG control loop to enable battery storage to become a dispatchable asset.

Suggested Action(s): 1-2 years – Medium Priority

- Determine the most (contextually) effective charge/discharge schedule and communicate it. *(Note: Real time signals like pricing or demand are an alternative to preset scheduling; real-time response is currently available from hardware.)*
- Standardize the data interface among components of a solar-plus-storage device (storage, inverter, etc.), perhaps following the MESA-Device/SunSpec Energy Storage Model specification.

Suggested Action(s): 3-5 years – Medium Priority

- n/a

Suggested Action(s): >5 years – Medium Priority

- n/a

These actions represent opinions from the workshop attendees. They do not reflect industry or attendee consensus and are not based on comprehensive research and analysis.

Challenge: Economics, Market Design, and Regulatory Barriers

Suggested Action(s): 1-2 years – High Priority

- Develop access to markets and revenue streams for energy storage (e.g., distribution-level demand response markets/programs that allow storage participation; RTO/ISO markets [FERC] vs. vertically integrated markets [states-controlled]; Define requirements for achieving the value set, including definition of context.
- Develop PPAs and tariff rates that can be applied to the addition of energy storage to existing DER sites.
- Develop guidelines and a standard expression for measuring the costs and benefits (i.e., the value contribution) of energy storage's individual and multiple services.

Suggested Action(s): 3-5 years – High Priority

- Resolve regulatory barriers on cost recovery considering energy storage's reliability/resiliency benefit vs. market-based revenues; determine an equitable approach for handling the allocation of upgrade costs due to project interconnection.
- Determine how to harmonize wholesale energy markets with retail tariffs intended for energy storage.
- Create more incentives for PV+storage installation that benefit both the grid and the project.
- Allow for preferred (lower) electric rates for battery and fuel cell zero-emission vehicles (ZEVs).

Suggested Action(s): >5 years – Medium Priority

- n/a

Suggested Action(s): 1-2 years – Medium Priority

- Clarify/determine conditions for utility ownership of energy storage.
- Clarify/determine how multiple contracts on a single energy storage device can be facilitated.
- Clarify/determine how utilities can rate-base long-term service agreements for NWAs.

Suggested Action(s): 3-5 years – Medium Priority

- n/a

Suggested Action(s): >5 years – Medium Priority

- Develop real-time distribution pricing so energy storage can monetize / provide services. *(Note: real time signals like pricing or demand are technically feasible today given that real-time response is available from hardware.)*

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Challenge: Education

Suggested Action(s): 1-2 years – High Priority

- Educate regulators about the technical and modeling differences between solar PV vs. energy storage interconnection (e.g., at a NARUC meeting session).
- Coordinate education among AHJ's, inspectors, regulators, and utilities about issues and best practices surrounding the adoption of IEEE Std 1547-2018.
- Identify and clearly define reasonable expectations and limitations of energy storage capabilities to help focus the technology's goals and objectives.
- Provide developers and DER customers with general process describing how storage projects progress from development through to installation and commissioning; offer guidance/training on technical- and cost-related interconnection issues: requirements, application evaluation/how to, resolution, etc.
- Educate first responders on safety-related issues.
- Lay out the impacts of NFPA 855 (Standard for the Installation of Energy Storage Systems) on utilities, third-party developers, and customers.
- Identify and aggregate available resources and references (a working clearinghouse) related to energy storage interconnection: standards, certification, research, use case examples, stakeholders, etc.

Suggested Action(s): 3-5 years – High Priority

- Conduct ongoing pilot programs that explore the merits of different energy storage applications, interconnection approaches, market constructs, system analysis approaches, battery and round-trip efficiency degradation, and effects, etc., and publicly report out results.
- Determine insurance that will be required—now and in the future—after big events, storms, fires, etc.

Suggested Action(s): >5 years – High Priority

- n/a

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Challenge: Education (2)

Suggested Action(s): 1-2 years – Medium Priority

- Develop a list of common/acceptable energy storage equipment and specifications (a la CA's Self-Generation Incentive Program [SGIP]), which stipulates approved manufacturers/products.
- Develop and share access to real data for industry research and analysis.
- Provide guidance to utilities about how to handle existing DER units in the field that are not up to 1547.1 (i.e., what are potential issues with grandfathering? what are costs to replacing?).

Suggested Action(s): 3-5 years – Medium Priority

- Consider and inform stakeholders about the extreme saturation of DER and other impacts of a 100% renewable future.

Suggested Action(s): >5 years – Medium Priority

- n/a

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Challenge: Hosting Capacity Analysis

Suggested Action(s): 1-2 years – High Priority

- Improve hosting capacity analysis approaches so that they better account for the attributes of energy storage with a control system (which should not necessarily be considered added load and require upgrades) as well as distribution system conditions.
- Adapt hosting capacity analysis models to add more granularity in real time (e.g., real-time hosting capacity maps that meet cyber security requirements).

Suggested Action(s): 3-5 years – High Priority

- Develop forecasting methodologies that do not consider net adjusted loads, but account for true load/resources (solar, storage, DSM, etc.).
- Consider the tradeoff and visibility of modeling on an 8760- vs. peak-hour-basis.
- Develop better models that identify by phase—not 3Ø value—to improve online hosting capacity maps.
- Improve data quality for DG, circuit maps, and uncertainty of projects that lead to hosting capacity limitations.

Suggested Action(s): >5 years – High Priority

- Publish utility needs and locations (in real time) where storage could help the most.
- Develop clear rules from regulators on how hosting capacity, load flow, and other electrical studies should proceed.

Suggested Action(s): 1-2 years – Medium Priority

- Publish regularly-updated (frequently) hosting capacity maps online that offer greater transparency and granularity.

Suggested Action(s): 3-5 years – Medium Priority

- n/a

Suggested Action(s): >5 years – Medium Priority

- n/a

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Challenge: Protection & Transformer Issues

Suggested Action(s): 1-2 years – High Priority

- Determine the cost implications of requiring recloser installs on customer premises.
- Develop an inventory of faults that are occurring in the field to determine best practices approaches.
- Validate the ability of DERs to detect and isolate an island. Address gaps in testing around anti-islanding functions.
- Explore alternatives to direct transfer trip (DTT) that are equally effective.
- Assess the risks of delta-wye transformers on the DER side of the point of common coupling (PCC). Evaluate the cost benefit of using zig zag or grounding transformers.

Suggested Action(s): 3-5 years – High Priority

- Identify and incorporate assets that can quickly clear distribution faults but ride-through transmission faults.

Suggested Action(s): >5 years – High Priority

- n/a

Suggested Action(s): 1-2 years – Medium Priority

- n/a

Suggested Action(s): 3-5 years – Medium Priority

- n/a

Suggested Action(s): >5 years – Medium Priority

- n/a

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Challenge: Standards/Utility Procedural Reform

Suggested Action(s): 1-2 years – High Priority

- Develop transparent/clarified guidance on energy storage interconnection process, costs (study and permitting), permitting, safety, and timeframe/deadlines, queue management, and grounds for material modification. This includes consensus solutions for efficiently studying energy storage and solar-plus-storage devices (e.g., nameplate capacity), and approaches based on project size or risk.
- Address EV charging load profiles as a standard consideration for interconnection considerations.
- Initiate PUC proceedings to establish/update statewide interconnection standards/levels for energy storage. Aim for consistency across jurisdictions. Ensure multi-stakeholder engagement.
- Expedite the implementation of 1547 standards (e.g., 1547.1 - testing standards for compliance) and guidelines, UL certifications.
- Determine how solar-plus-storage should be studied and modeled (e.g., As stacked MW's? Operational during daytime hours? Seasonal? Etc.)
- Reform internal utility interconnection processes to better share responsibilities across utility departments and enable faster review and more coordinated system planning. This includes incorporating utility actors involved in DER interconnection and planning into the IRP process.
- Develop/adapt interconnection applications that are more specific to energy storage. DER applications (including those for microgrids) do not always adequately accommodate battery storage or are confusing to customers. These should be modified to reduce unnecessary requirements or address unique considerations.
- Investigate utility visibility into behind-the-meter DER operation to better manage grid operations.
- Streamline the interconnection permitting process in a way that upholds safety/reliability and reduces approval time.

Suggested Action(s): 3-5 years – High Priority

- Develop national standard for designing inverter-based DER and their systems.
- Address barriers to customer-side microgrids. The parallel vs. islanded interconnection process is too long.

Suggested Action(s): >5 years – High Priority

- Enable on-demand, seamless, electronic interconnection. Automate the behind-the-meter interconnection approval in minutes.

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Challenge: Standards/Utility Procedural Reform (2)

Suggested Action(s): 1-2 years – Medium Priority
• Streamline the utility testing/review process by publishing concise checklists that leverage HIL, etc. • Develop online interconnection application portals.

Suggested Action(s): 3-5 years – Medium Priority
• Develop operational standards concerning the responsibilities between utility companies and operators/facility.

Suggested Action(s): >5 years – Medium Priority
• Clarify the operating requirements of a large number of (relatively) smaller assets aggregated by balancing area or network section. Assess the possibility for failure or abnormal/out-of-bounds operation.

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Challenge: Tariff Compliance & Metering

Suggested Action(s): 1-2 years – High Priority

- Clarify metering requirements for interconnecting battery storage (e.g., DC- vs. AC-side of project implementation, traditional meter vs. advanced inverters functions).
- Certify DER inverter metering accuracy.
- Adopt tariffs that account for the full value stack of energy storage and that address perverse incentives (e.g., BESS customer export during coincident system peak in parallel with PV system, rather than during residential peak). Determine how value streams can be baked into tariff structures and programs (demand response, frequency regulation, etc.). Sample questions: Who pays for the interconnection and use of the BESS? What does the utility gain?

Suggested Action(s): 3-5 years – High Priority

- Resolve metering differences when PV is legislated as a renewable and energy storage is not. Address how metering should be applied to solar-plus-storage interconnection (i.e., to resolve net metering) through metering or otherwise.
- Align tariffs between utilities/ISOs to overcome retail versus wholesale participation issues for behind-the-meter storage.

Suggested Action(s): >5 years – High Priority

- Develop a gradation in the metering standard from full ANSI to basic accuracy.

Suggested Action(s): 1-2 years – Medium Priority

- Determine if ANSI can certify meters internal to other equipment, such as inverters, chargers, etc.
- Understand gaps in standards that would need to be filled to enable integrated revenue-grade metering and communication to those meters. Does ANSI have a relevant standard for "revenue-grade DC metering"? How should conversion losses in a hybrid inverter be accounted for?
- Improve inverter data accuracy / ANSI-certified distribution metering.

Suggested Action(s): 3-5 years – Medium Priority

- Create standards that allow revenue-grade, device-level submetering.

Suggested Action(s): >5 years – Medium Priority

- n/a

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Next Steps

- The stakeholder identified challenges and solutions are meant to provide informal guidance from a range of perspectives to industry stakeholders on prioritized issues in need of development, refinement, and/or further study.
- Stakeholders are encouraged to identify those suggested actions that they are well positioned to lead.
- Where appropriate, stakeholders are also encouraged to seek out partnership and collaboration. This could involve:
  - Identification and sharing of data useful to furthering understanding
  - Creation of voluntary working groups
  - Participation in existing industry groups, such as the Energy Storage Integration Council (ESIC), Forum on Inverter Grid Integration Issues (FIGII), standards development committees (e.g. IEEE), among others
  - Participation in regulatory proceedings.

- Actions will also be referenced to help inform activities at EPRI, NREL, and other research institutions.
- Future DGIC research, webcasts, and events will aim to continue the dialog and report out progress, developments, leading practices, and remaining challenges.

Workshop Proceedings

ELECTRIC POWER
RESEARCH INSTITUTE

Overcoming Challenges for DER Interconnection

Spotlight on Energy Storage

Nadav Enbar, EPRI

Distributed Generation Integration Collaborative (DGIC) Workshop
July 29, 2019

www.epri.com

Welcome and Workshop Objectives

- Running time: 1:00-4:30 pm ET
- Topical focus and flow
  - Current challenges of interconnecting energy storage to distribution
  - Field experiences, regulatory perspectives
  - Brainstormed solutions to address identified gaps and shortcomings
- Open dialog format!
  - Workshop a "safe space" for sharing perspectives; respect thy neighbor

rap·por·teur (*noun*)
/ˌraˌpôrˈtər/
A person appointed by an organization to report on the proceedings of its meetings.

End Goal: Development of a research roadmap for advancing the interconnection of energy storage and its integration with other DERs, such as solar (PV).

Distributed Generation Integration Collaborative (DGIC)

- Supported by U.S. DOE SunShot Initiative, formed in October 2013
  - EPRI leading DGIC starting in 2019
- Originally focused on informational exchange and innovation related to distributed PV interconnection processes and practices
  - Focus newly expanded to encompass DER integration topics

Distributed Generation Integration Collaborative

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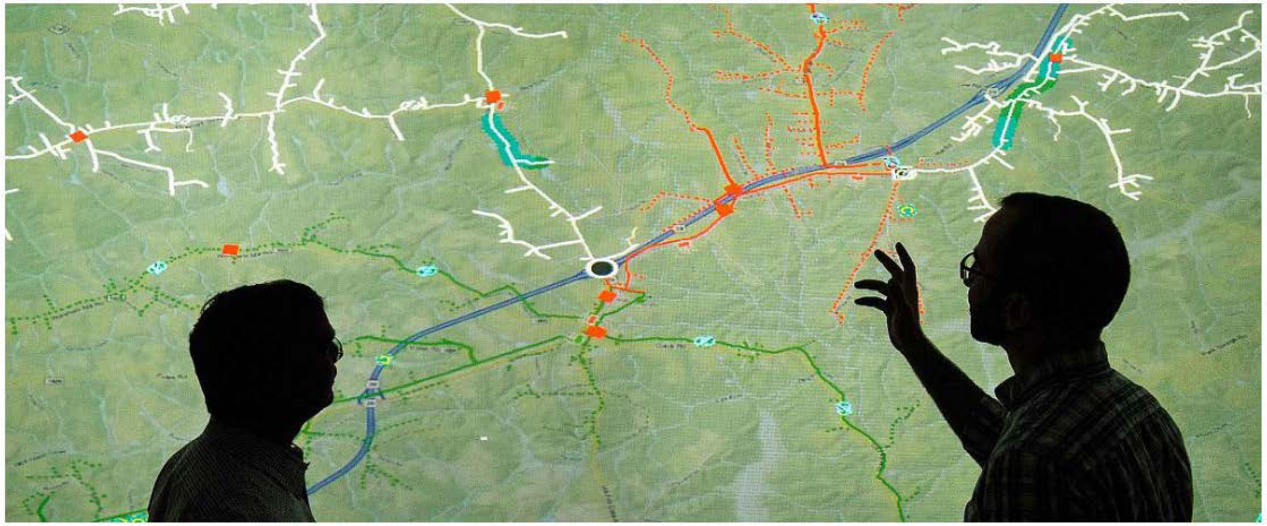

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

DGIC Research Areas

- **Research**
- Interconnection
- Business Models & Regulation
- Technologies & Mitigation Methods

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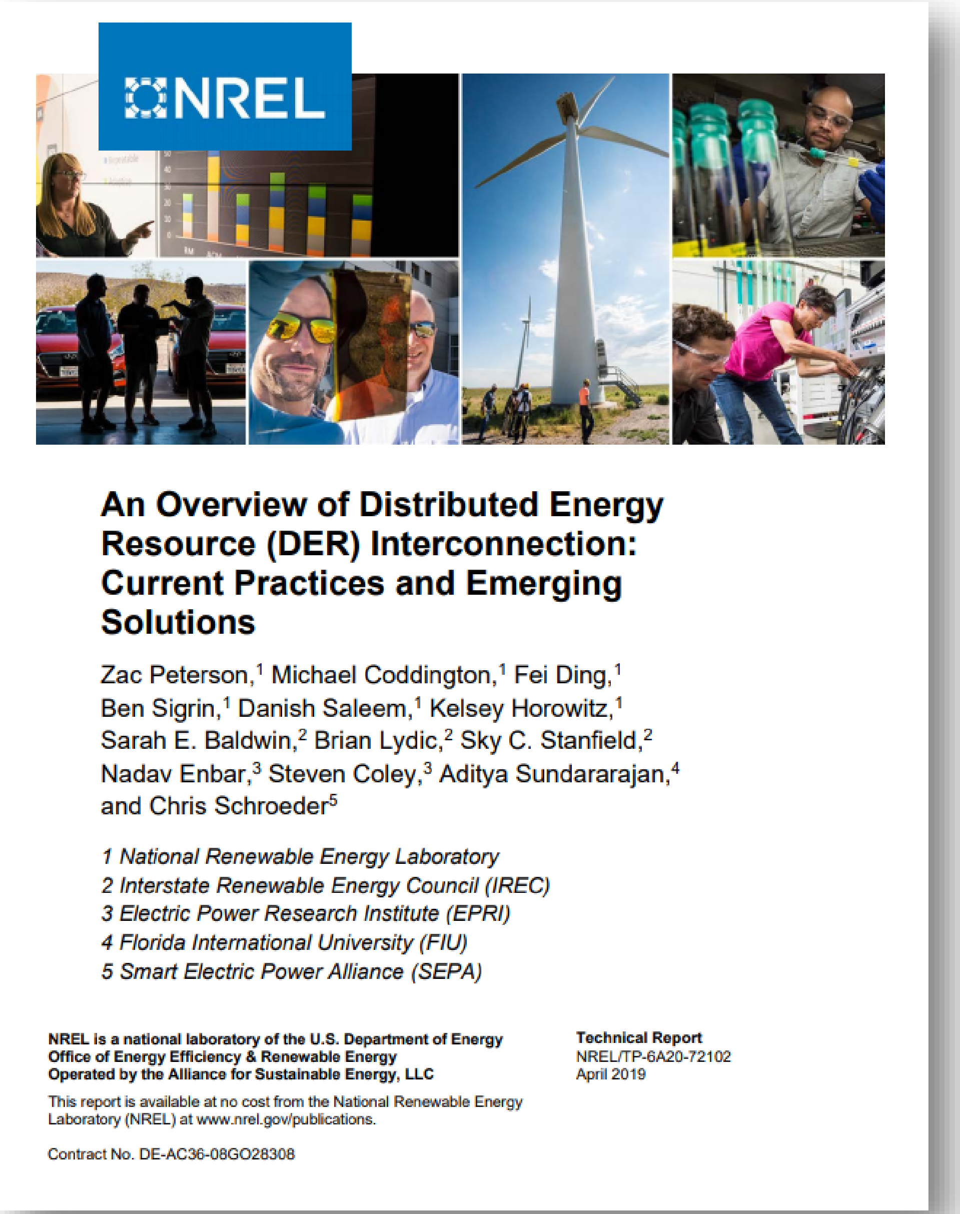
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Office of Energy Efficiency & Renewable Energy
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This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-6A20-72102
April 2019

We Value your Input!

- Let us know what unanswered research questions, needs, and industry gaps the DGIC should explore.
- Subscribe to the DGIC newsletter to stay connected.

DGIC Leadership

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Workshop Agenda

TIME	TOPIC	KEY PARTICIPANT(S)
1:00 pm	**Introduction & Welcome** • DGIC Background • Workshop Objectives, Scope, and Logistics • Setting the Stage: Energy Storage Market Landscape, Expectations, and Problem Statement	*Nadav Enbar, EPRI*

1:15 pm	**Energy Storage Interconnection Challenges: Field Experiences**
	• Highlights of Encountered Complications
	  ○ Under-defined Operating Standards
	  ○ Tariff Compliance & Metering
	  ○ Protection & Transformer Issues
	  ○ Multi-Use Applications / Cross-Domain Functionality
	  ○ Hosting Capacity Calculation
		Morgan Smith, EPRI

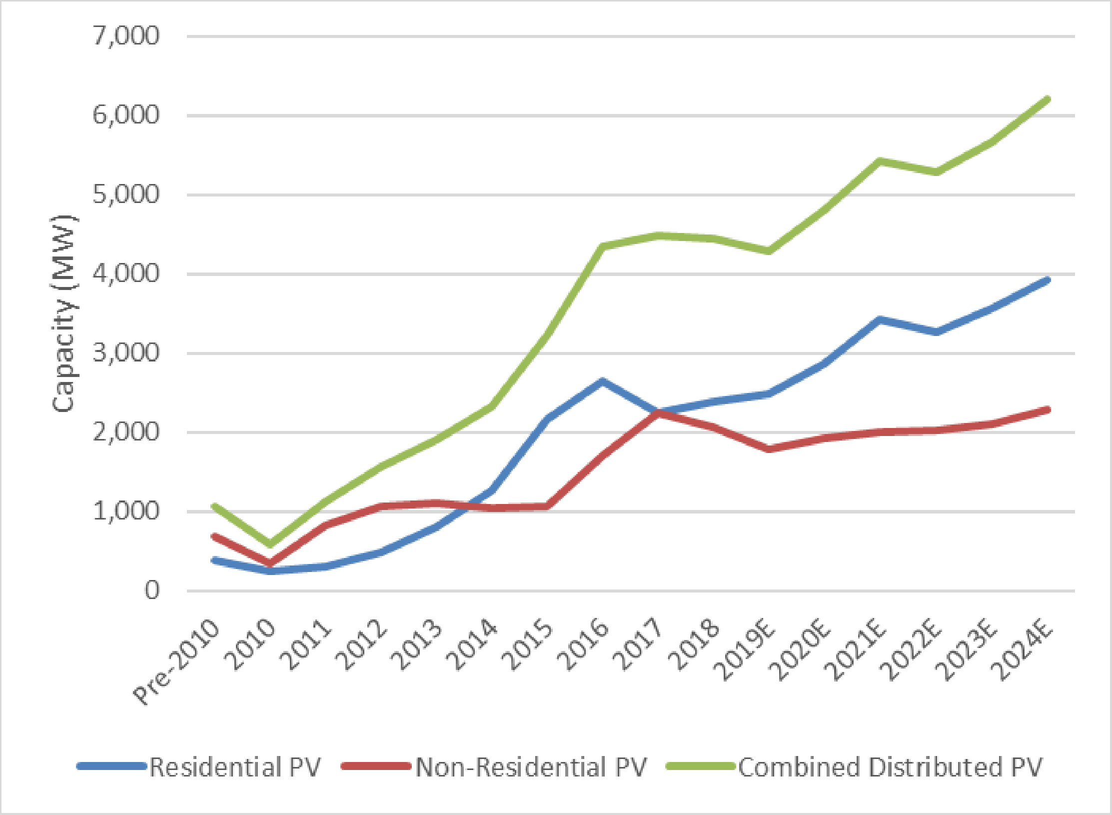
2:15 pm	**Developments: Standards, Guidelines, and Certifications**
	• Overview of IEEE Std 1547 Family of Standards
	  ✓ IEEE Std 1547-2018 – Standard for Interconnecting DERs with EPS's
	  ✓ 1547.1, 1547.2, 1547.3, 1547.9, others
	• UL 1741 – Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With DERs
	• IEEE Conformity Assessment Program (ICAP): Status, Pilot Learnings, Future Mapping to 1547-2018
		• *Shazreen Meor Danial, NREL*
		• *Jason Allnutt, IEEE*

Workshop Agenda (2)

TIME	TOPIC	KEY PARTICIPANT(S)
3:00 pm	**Break**	
3:15 pm	**Breakout: Action Plan for Efficient Energy Storage Interconnection** • Identification & Prioritization: Near- and Mid-term Actions for Advancing Energy Storage Interconnection ○ Facilitated Small Group Brainstorm, Report Out, General discussion ○ Among high-level questions to be broached: ✓ How can stakeholders collaborate on improving energy storage interconnection processes? ✓ What are the intersections for interconnection between energy storage and other DERs? ✓ What data is needed and how can this be shared?	• *Zachary Peterson, NREL* • *Group Discussion*
4:15 pm	**Closing Remarks & Next Steps** • Summary of Knowledge Gaps & Needs • Future DGIC Research Activities	*EPRI / NREL*
4:30 pm	**Adjourn**	

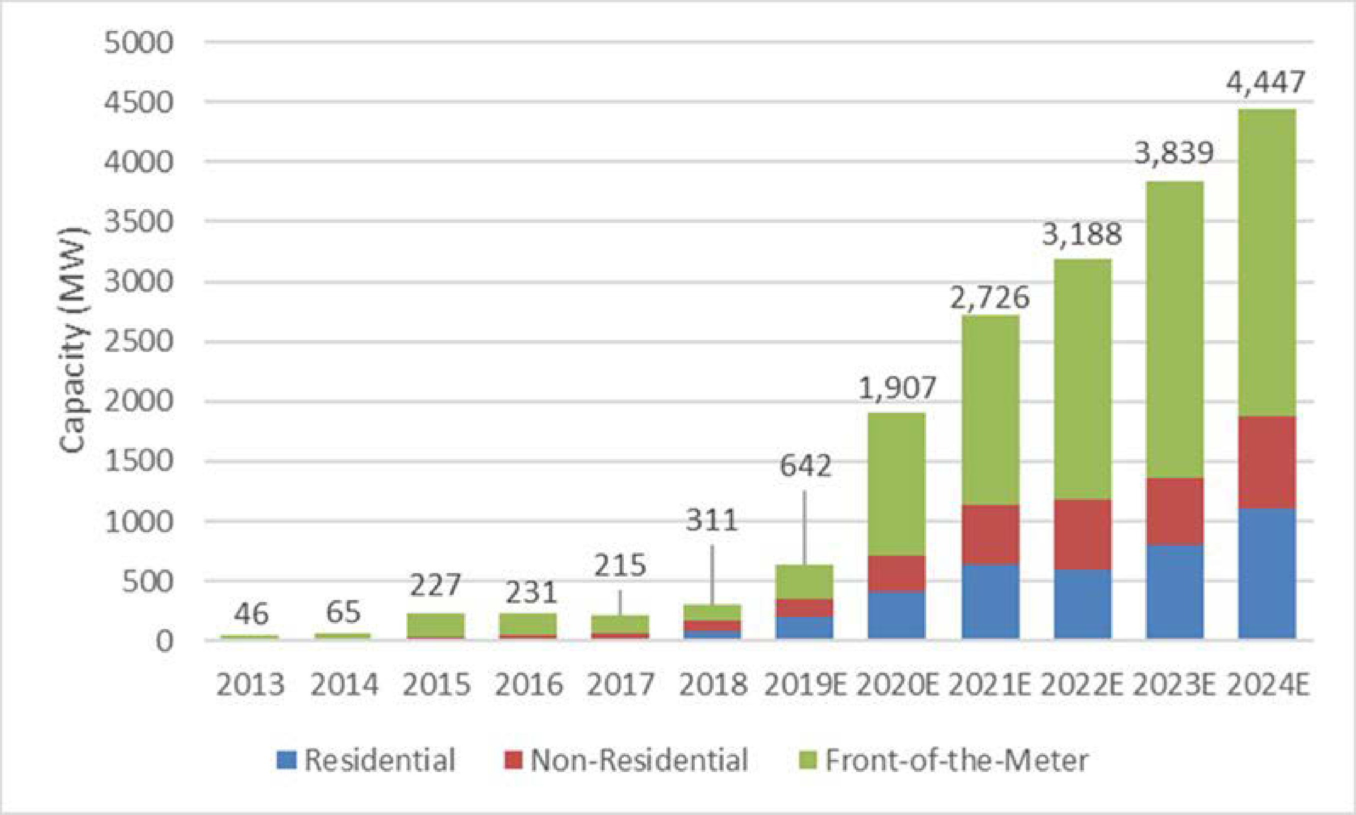
Energy Storage Market Growth Looking a lot like PV's

Annual U.S. Distributed PV Installations, 2010-2024E



Source: Wood Mackenzie Power & Renewables/SEIA U.S. Solar Market Insight, 2019
Note: Distributed PV installations include residential and non-residential projects, but exclude utility PV projects.

Annual U.S. Energy Storage Deployments (MW), 2013-2024E

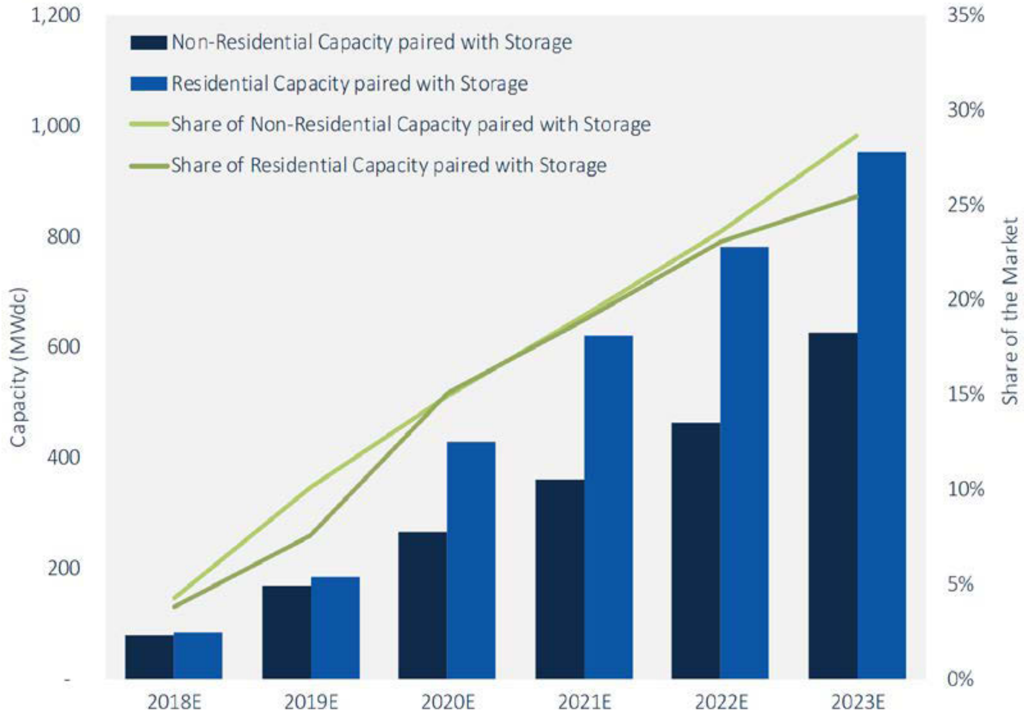


Source: EPRI, based on data provided by Wood Mackenzie and Energy Storage Association, U.S. Energy Storage Monitor 2018 Year in Review, March 2019.

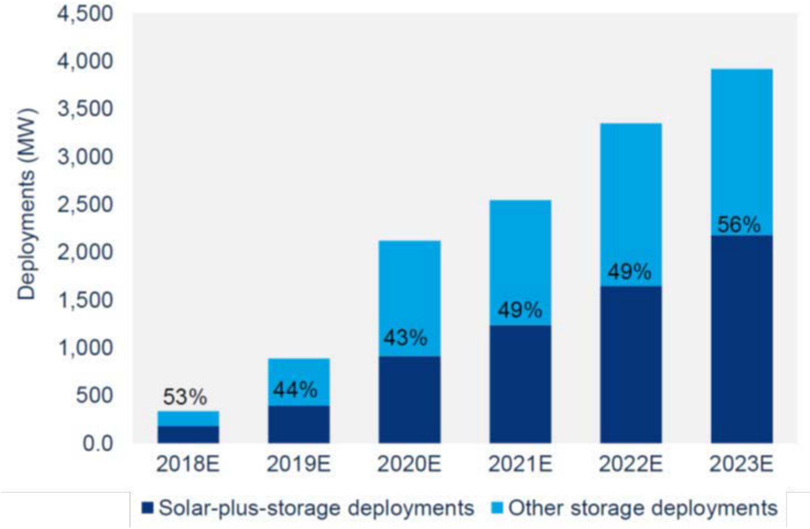
Setting the Stage

Solar-plus-Storage Deployment Ramping Up Too

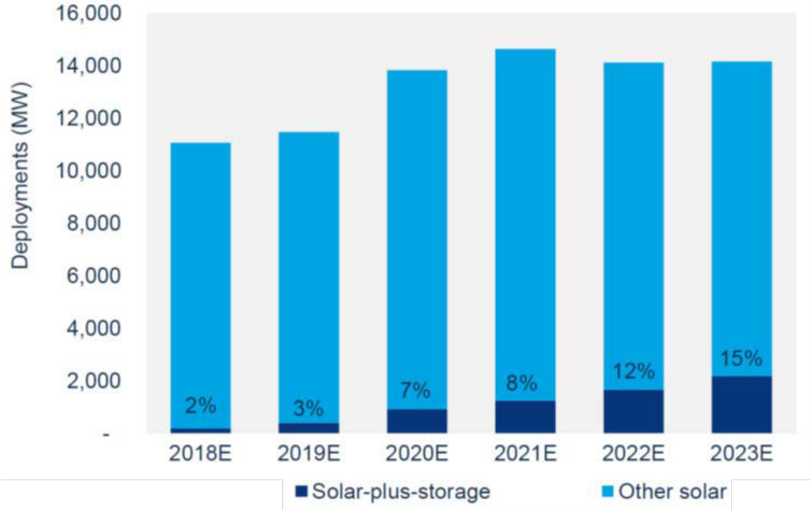
Anticipated U.S. Solar-Plus-Storage Deployments by Segment, 2018E-2023E (Dx-connected)



GTM Research, Energy Storage Monitor, 2018



% of Annual Storage Deployments (MW) Paired w/PV, 2018E-2023E

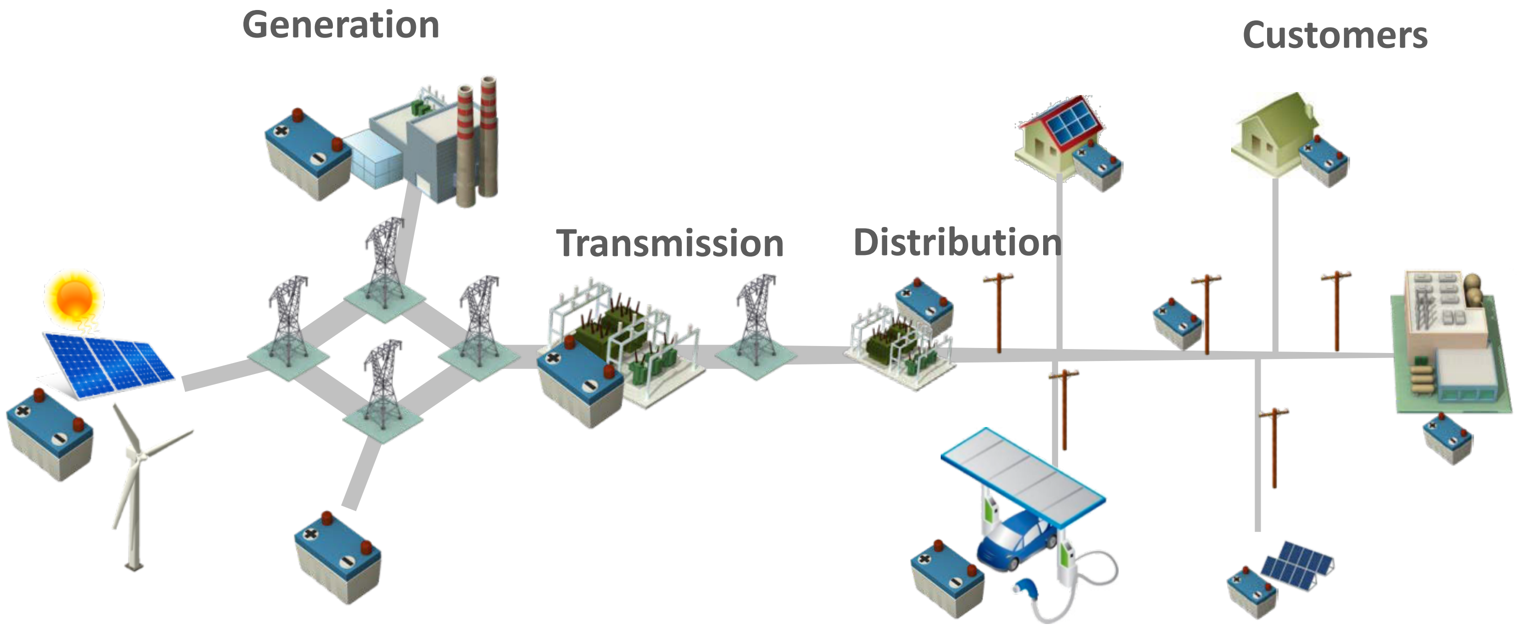


% of Annual Solar Deployments (MW) Paired w/Storage, 2018E-2023E

Wood Mackenzie Power & Renewables, Intersolar, May 2019

Selected Energy Storage Services / Value

- **Generation**
  - Resource Adequacy
  - Energy time-shift / arbitrage
  - Ancillary Services
  - ↑ **Transmission**
    - Investment Deferral
    - Congestion Relief
    - ↑ **Distribution**
      - Peak load management
      - Loss reduction
      - Voltage control
      - ↑ **Customer**
        - Demand Charge Reduction / arbitrage
        - Backup Power
        - Solar Self-Consumption



Value streams may be "stacked", depending on needs, location, and control

The Catch…

- A range of challenges are preventing energy storage from realizing value-stack opportunities (including those that can provide grid value)
- Technology is moving faster than regulation / market design
- Storage can address various needs and objectives (for multiple actors)…
- …but greater direction is needed to realize its potential without compromising grid safety and reliability

Reforms needed to enable efficient, cost effective interconnection

Closing Remarks / Next Steps

Next Steps

- Workshop materials to be posted on DGIC website
- Attendee follow up: Further guidance on priority actions
- Distilled report to be released following workshop
  - Characterization of challenges and regulatory activities
  - Presentation of initial research / reform roadmapping effort
  - References to relevant materials

Recommended Reading

- *An Overview of DER Interconnection: Current Practices and Emerging Solutions*, NREL/DGIC (2019)
  - https://www.nrel.gov/docs/fy19osti/72102.pdf
- *Energy Storage Integration Council (ESIC) Energy Storage Implementation Guide,* ESIC (2019)
  - https://www.epri.com/#/pages/product/000000003002013533/?lang=en-US
- *Review of Interconnection Practices and Costs in the Western States*, NREL (2018)
  - https://www.nrel.gov/docs/fy18osti/71232.pdf
- *Energy Storage Commissioning Guide*, ESIC (2017)
  - https://www.epri.com/#/pages/product/000000003002013972/?lang=en-US
- *Energy Storage Test Manual*, ESIC (2017)
  - https://www.epri.com/#/pages/product/000000003002011739/?lang=en-US
- *IEEE 1547 — New Interconnection Requirements for Distributed Energy Resources: Fact Sheet*, EPRI (2017)
  - https://www.epri.com/#/pages/product/000000003002011346/?lang=en-US
- *Assessing Opportunities and Challenges for Streamlining Interconnection Processes*, EPRI / DOE (2017)
  - http://mn.gov/commerce-stat/pdfs/solar-pathways-streamline-interconnection.pdf
- *High-Penetration PV Integration Handbook for Distribution Engineers*, NREL (2016)
  - https://www.nrel.gov/docs/fy16osti/63114.pdf
- *Changing Utility Cost Pathways amid Rising Deployment of Distributed Energy Resources*, EPRI (2016)
  - https://www.epri.com/#/pages/product/000000003002008211/?lang=en-US
- *Decreasing Soft Costs for Solar PV by Improving the Interconnection Process: A Case Study of Pacific Gas and Electric*, NREL (2015)
  - https://www.nrel.gov/docs/fy15osti/65066.pdf
- *A State-Level Comparison of Processes and Timelines for Distributed Photovoltaic Interconnection in the United States*, NREL (2015)
  - https://www.nrel.gov/docs/fy15osti/63556.pdf

Together…Shaping the Future of Electricity

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Energy Storage Interconnection Challenges

Field Experiences: SVUSD Bus Barn Microgrid Case Study

Morgan Smith, EPRI

Distributed Generation Integration Collaborative (DGIC) Workshop
July 29, 2019

Interconnection Stakeholders and Drivers

Utility

- Safety
- Reliability
- Financial Viability
- Familiar Equipment
- Familiar Processes
- Regulatory Compliance
- Environment

Integrator

- Financial Viability
- Financial Certainty
- Timeliness
- Safety
- Reliability
- Environment

Customer

- Low Energy Costs
- Reliability
- Convenience
- Safety
- Environment

Stakeholder Goals are not Mutually Exclusive

How can we better align them?

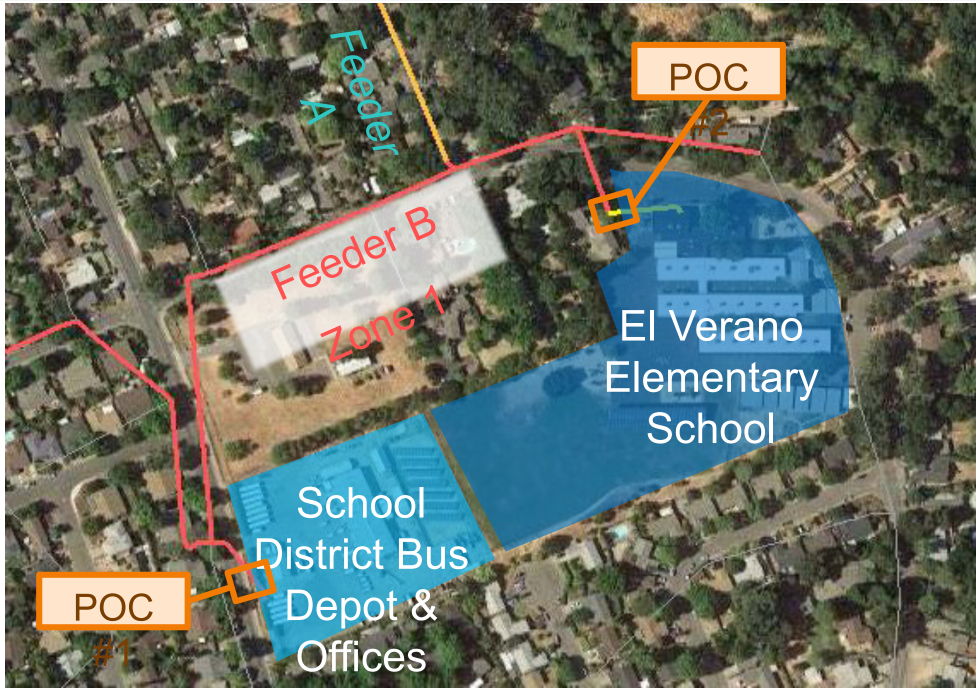
Agenda

- Case study describing the multiple values available from PV + storage
- Challenges to realizing multiple benefit streams
- Potential mitigations
- Blockers
- Questions and discussion

Comments and Questions Welcome throughout the Presentation

Background

- CEC GFO 16-309 funded project to demonstrate "Multi-Use Applications"
- Among other prerequisites, solicitation required:
  - ✓ Front-of-meter installation
  - ✓ Providing resilience (backup power)
  - ✓ Installation on a feeder with high renewables penetration



Feeder Name	SONOMA 1104
Feeder Number	042721104
Nominal Circuit Voltage (kv)	12kV
Circuit Capacity (MW)	12.19
Circuit Projected Peak Load (MW)	6.59
Substation Bank	1
Substation Bank Capacity (MW)	29.700001
Substation Bank Peak Load (MW)	21.860001
Existing Distributed Generation (MW)	1.58
Queued Distributed Generation (MW)	0.12
Total Distributed Generation (MW)	1.7
Total Customers	3261
Residential Customers	2938
Commercial Customers	211
Industrial Customers	24
Agricultural Customers	72
Other Customers	16

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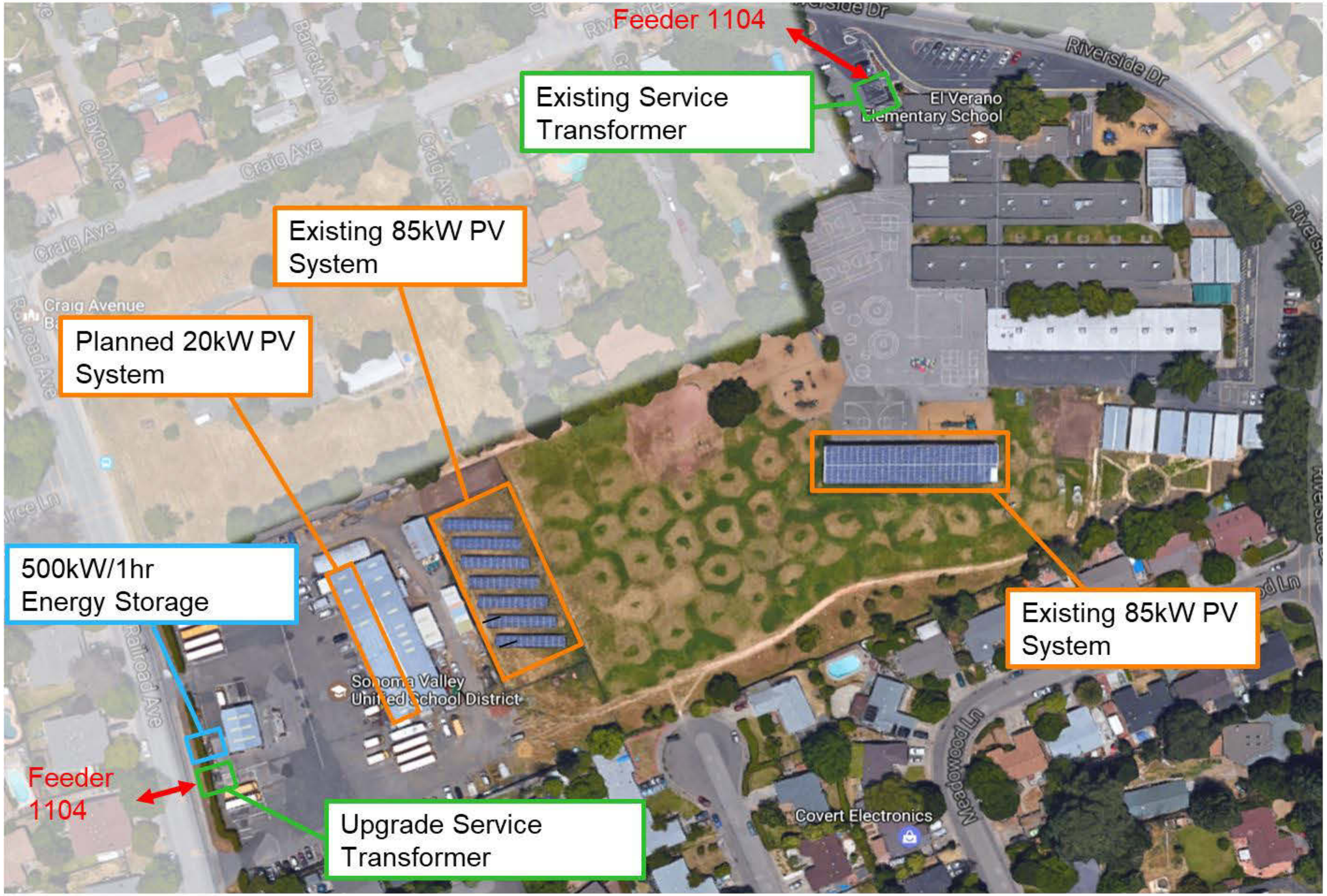
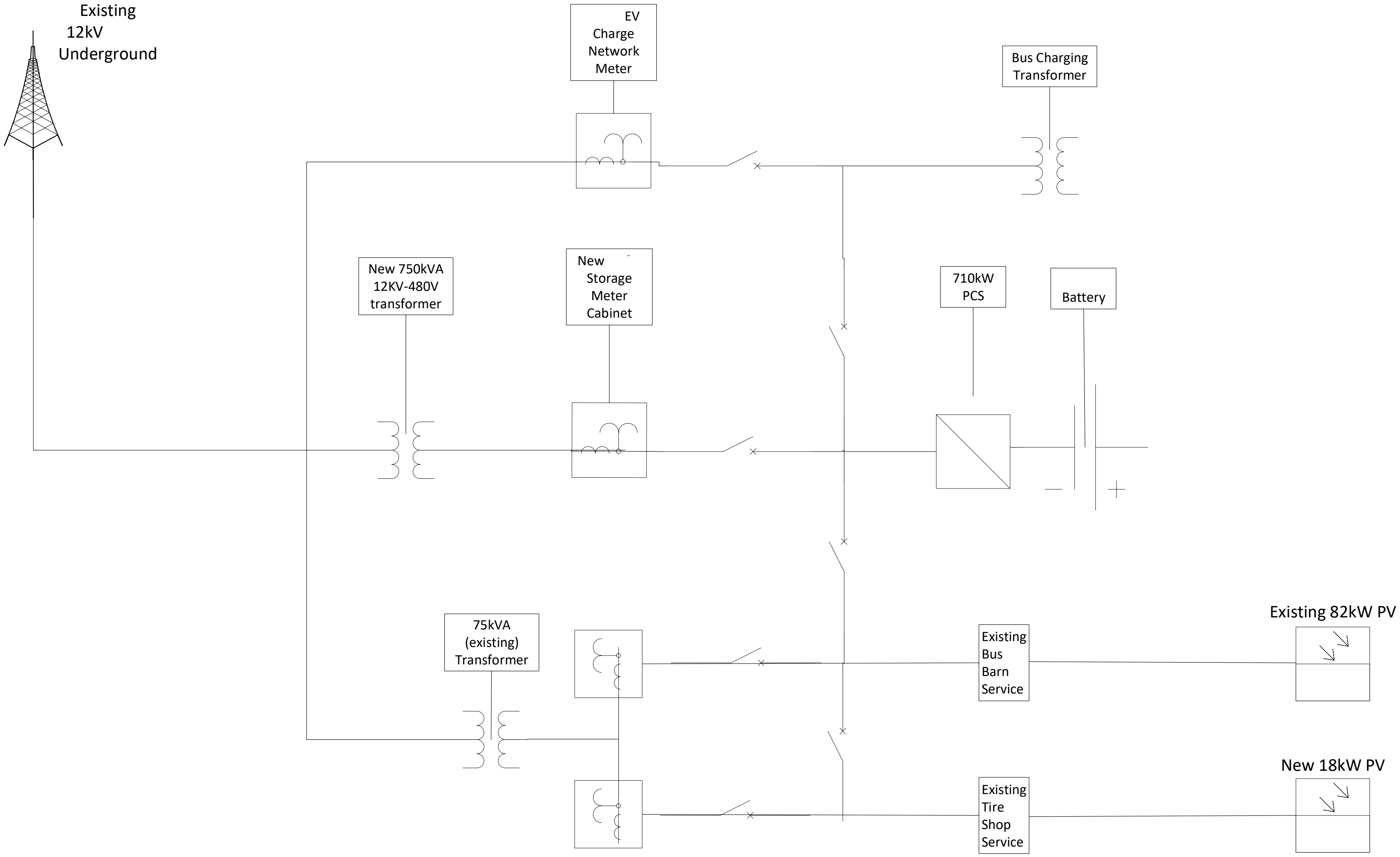
Key Research Questions

1. How can assets provide services across multiple domains?
2. Do standards prevent this, and how can they be modified to protect all stakeholders?
3. How can advanced inverter functions supplant infrastructure improvements?



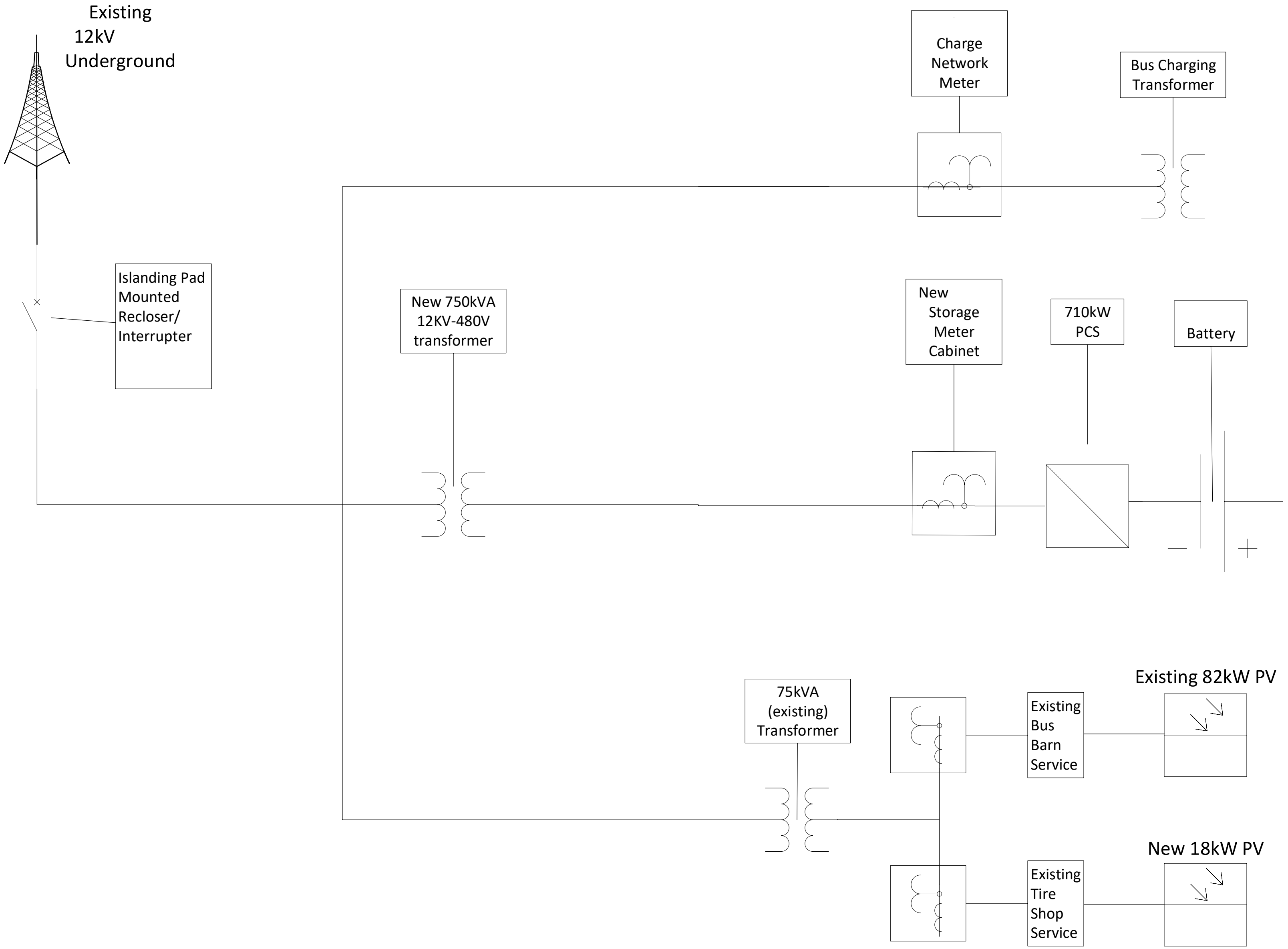
LV Transfer Arrangement

- At right: a transfer switch arrangement more typically used to provide backup power
- 28 poles of switching to achieve same results as a single recloser
- Arrangement does not provide tariff-compliant metering since during backup retail loads may receive wholesale power



Primary Service with Customer Recloser

- This arrangement appears to provide tariff-compliant metering with all power flows metered and billed appropriately
- Non-standard in that a customer recloser is installed on customer premises but in front of the meters
- Requires approval of non-preferred metering arrangement
- Mechanisms for shared data and control from recloser are beneficial but lacking, initial recommendation was to add a second recloser, but still in utility domain



Summary + Preliminary Review

- Aug. 2017: Funded
- Separate PV + ES Interconnections
- 8/28/17: Initial application for interconnection
- 10/4/17: Reapplication, (Post R21, Ph 1)
- Extensive documentation requests
- 12/20/17: Initial review received
- 3/13/18: Supplemental Review received
- 4/18/18: Draft SGIA received
- 19 five-day delay notices received in total
- 7/18: Application withdrawn due to excessive costs
- 8/18-present: Negotiation
- 6/19: Re-application

Screen 2 - Aggregate generation ≤ 15% of line section peak load?
For interconnection of a proposed Generating Facility to a radial distribution circuit, the aggregated generation, including the proposed Generating Facility, on the circuit shall not exceed 15% of the line section annual peak load and on the bank shall not exceed 15% of the line section annual peak load as most recently measured at the substation. A line section is that portion of a Distribution Provider's electric system connected to a customer bounded by automatic sectionalizing devices or the end of the distribution line.

Order of devices	Source Side Protective Device	Peak at the device (kW)	Existing Generation (kW)	Queue Project (kW)	Proposed Project (kW)	Aggregate Capacity (kW)	% of Peak Load	Exceeds?
1	412	1014	246	0	500	746	73.6	Yes
2	414	6062	1303	0	500	1803	29.7	Yes
3	1104	8910	1403	18	500	1921	21.6	Yes
	SONOMA_BK1	26640	4206	5618	500	10324	38.8	Yes

The total of both project generation and existing generation is more than 15% of at least one line section's peak load.
FAIL Screen 2

15% of Peak May not be a Viable Metric

Supplemental Review

- Supplemental Review Required
- $2,500
- Received 3/13/18
- Labelled as "Passed"
- But Required SCADA Recloser

Fault
Location
Isolation
Service
Restoration

3.3.6 Automation Circuit (FLISR)

This project is being proposed on an automation feeder. This means that the project can be automatically be switched to an alternate feeder. Since this study is limited to the proposed POI and feeder, the issues that could result from the project being switched to an alternate feeder are unknown. Therefore a POI SCADA recloser is required to ensure that PG&E operations have the ability to remotely disconnect the project to mitigate for any adverse impacts that results from an abnormal switching.

Mitigations

- Install a SCADA POI recloser to be used for generator control (if needed) after a FLISR operation

Recloser Required "just in case"

SGIA Received

Interconnection Facilities (Subject to Cost-of-Ownership)	Costs
Pre-parallel inspection, protection review and testing witnessing	$5,000.00
Secondary Revenue Metering	$5,000.00
Replace existing 75kVA 120/208V transformer will be upgraded to 750kVA 277/480V.	$56,000.00
Secondary service re-arrangement	$30,000.00
SCADA Recloser at POI - SCADA POI recloser to be used for generator control (if needed) after a FLISR operation	$90,000.00
Visible, Lockable Disconnect Switch (by IC)	n/a
Total -- Interconnection Facility Costs *(Subject to Cost-of-Ownership)*	**$186,600.00**
ITCC Tax[1]	**TBD**

Cost Category	Amount Subject to COO ($)	Amount NOT Subject to COO ($)	Total Cost Category Amount ($)
Interconnection Facilities Costs (Attachment 2)	**$186,600.00**	**N/A**	**$186,600.00**
Distribution Upgrade Costs (Attachment 6)	**$7,500.00**	**N/A**	**$7,500.00**
Network Upgrade Costs (Attachment 6)	**N/A**	**N/A**	**N/A**
Total Project Costs ($)	**$194,100.00**	**N/A**	**$194,100.00**

A. Monthly Cost-of-Ownership Charge

$ 194,100.00 x 0.48%[1] (current percentage rate) = $931.68

B. **Equivalent One-Time Charge** (in lieu of recurring Monthly Cost-of-Ownership Charge)

$ 931.68 / month x 12 months x 14.28 (present worth factor[2]) = $ 159,652.68

$354,000 to Interconnect 0.5MW

Challenge #1: Wholesale Distribution Tariff – Cost Inefficiency & Unknowns

WDT Costs

- $194,100; COO = $159,653 (or $931/mo) = $354,000
- CPUC allows 0.48% COO charge for "customer financed special facilities"
- "True up" of actual COO expected, but estimates or cost justifications are not available upfront
- $62,000 to reconfigure to BTM after study
- $8,000 for applications, studies etc.
- Total = $423,753 or $0.85/W

WDT Revenue (StorageVET book-end estimates):

- DA Time Shift: $12,988/yr (assumes no other constraints)
- Co-optimization (energy, FR, reserve): $78,632/yr

Additional costs

- Scheduling coordinator fees: ~$60k/yr (first year), $35k/yr (ongoing)
- No metering regulations exist for billing of auxiliary loads; hard to estimate, ~ ($10k-$15k)/yr

Construction Delays – Minimum of 12 months for planning after SGIA, no process

Installed Costs (~$1M) – Revenue ($30k/yr.) = non-viable payback

Challenge #2: FTM Contradicts New CPUC MUA Rules

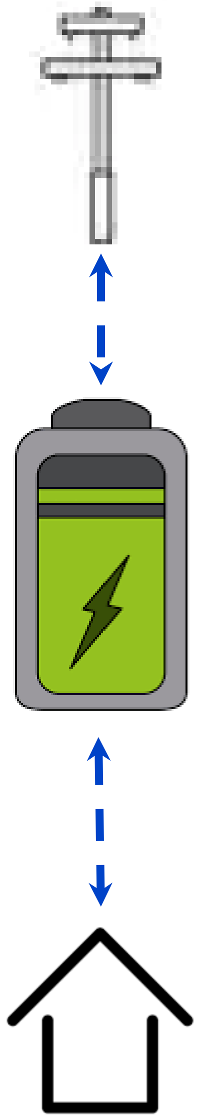
- CPUC Decision 18-01-003 (January 11, 2018)
  - **A resource can provide *compensated* services in the domain to which it is interconnected, and domains upstream**
  - Under this framework, FTM storage should not provide backup power to a single customer, exemption for community storage

Domain	Reliability Services	Non-Reliability Services
Customer	None	TOU bill management; Demand charge management; Increased self-consumption of on-site generation; Back-up power; Supporting customer participation in DR programs
Distribution[7]	Distribution capacity deferral; Reliability (back-tie) services; Voltage support; Resiliency/microgrid/islanding	None
Transmission	Transmission deferral; Inertia*; Primary frequency response*; Voltage support*; Black start	None
Wholesale Market	Frequency regulation; Spinning reserves; Non-spinning reserves; Flexible ramping product	Energy
Resource Adequacy	Local capacity; Flexible capacity; System capacity	None

FTM deployment with backup service not aligned with CPUC MUA framework

Core Issues

- Most energy storage installations could provide additional value streams across domains beyond their primary function and domain of interconnection
- To provide backup, it is necessary that the islanding switch be upstream of both retail and wholesale meters
- Multi-use applications involving a wholesale asset and a retail asset will necessarily be linked by traditionally utility-domain lines and/or will involve metering configurations other than current common standards
- Due to the recent advent of MUA installations, tariff-compliant standards for metering and installation do not exist
- Presuming non-preferred arrangements are possible, who can provide guidance on what is and isn't possible?
- Established processes are selected over new technologies, increasing costs, so how can we create familiarity with the capabilities of newer technologies?



Unintentional Islanding

- Unintentional islanding of inverters is a widely held concern

- Often utilities will require visible contact disconnects, reclosers, and/or direct transfer trip arrangements primarily to make sure inverter(s) are off when they should be

- UL 1741 provides for testing and listing of inverters, a large portion of which is dedicated to anti-islanding

Unintentional Islanding

- Inverters are designed, built, tested, and listed specifically not to unintentionally energize a faulted or disconnected grid
- NREL and others have completed substantial anti-islanding testing, including inverters with new autonomous grid support functions.
  - https://www.nrel.gov/docs/fy16osti/66942.pdf
- Is anyone aware of an event involving unintentional islanding of a listed inverter?

How can utilities get more comfortable with inverter functions?

SCADA Reclosers vs. Inverter Control

SCADA Recloser

+ Established
+ Reliable
+ Known Process

- Costly
- Maintenance
- Binary Output

Inverter Control

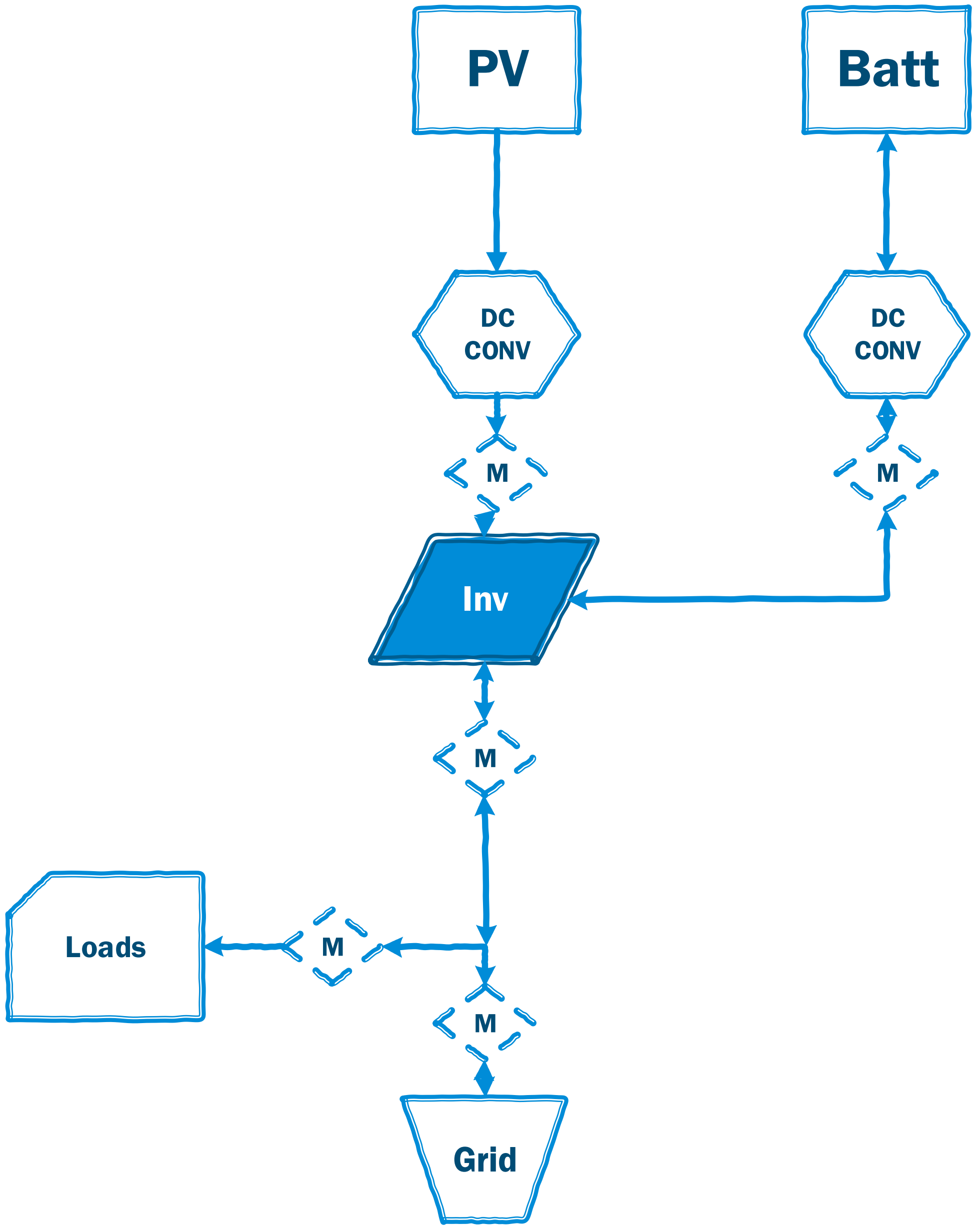
+ Inexpensive
+ 4 Quadrant Variability
+ Autonomous Capability

- Relatively Unknown
- Process Emerging
- Lack of Confidence

- Current processes give grid operators the ability to shutoff larger distributed assets using a recloser
- With storage the direction and magnitude of load step in the event of disconnection may be unknown
  - ✓ This load step may not be beneficial to operator goals during a fault
- Inverter control can allow 4-quadrant variability during an event, enabling more options for operators

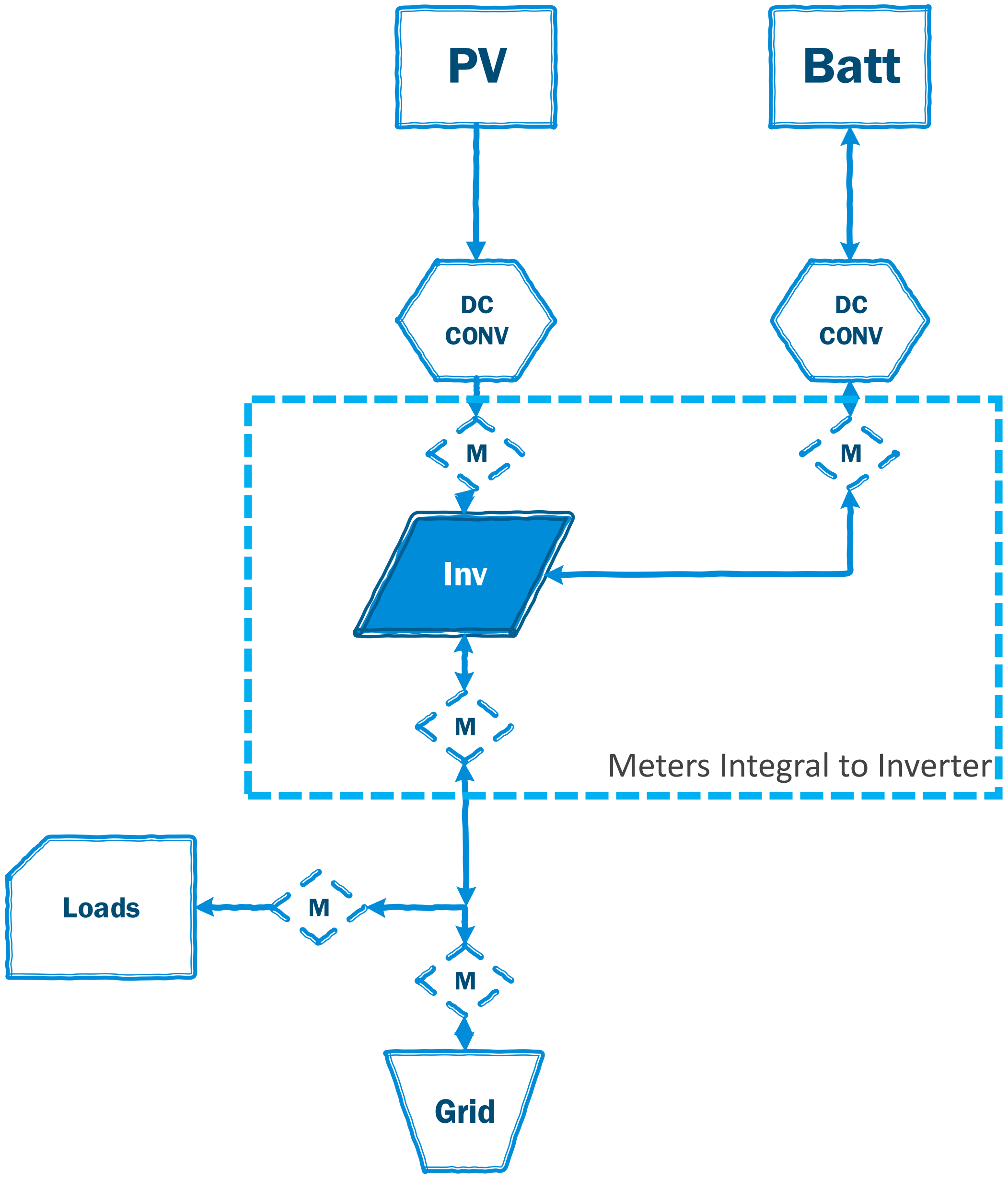
Metering Challenges

- Many utilities are requiring generation meters on PV/storage for BTM storage+ installs
- Confirm: primary concern is resale of power from non-renewable sources
- Revenue Grade PV metering is costly and in the case of DC coupled systems much more so
- Lack of comfort with inverters as meters
  - Lack of physical security of metering points
  - Unfamiliarity with hardware
  - Accuracy concerns
  - Accounting for conversion losses



Potential Mitigations

- ANSI-certified inverter meters
- Meters with additional external CT or shunt
- Standards that prevent tampering with hardware or settings associated with inverter meters
- Standards that enable import lockout for batteries coupled with renewables
- Standards that enable export lockout for batteries without renewables
- What steps are possible to prevent installation of many separate meters?



Progress

- "Storage projects less than 30kW that are paired with and charging from on-site renewable generators must have the ability to provide data in the event of an audit, and may utilize metering and monitoring equipment that is already part of the system."
  - SGIP Handbook 2017
  - https://www.selfgenca.com/home/resources/
- The alternative →

Can Redundant Functionalities be Reduced?

- 1741 appears to covers anti islanding pretty well
  - What is lacking?
  - Testing?
  - Certifications?
- How are inverters different from rotating machines?
  - Short circuit characteristics
  - No inertia, minimal fault current availability
  - Will not carry a load without a grid source or a mode transition PQ to VF
- Telemetry – copper T1 vs. cell vs. WIFI vs. autonomous
- Is supervisory control necessary with autonomous functions?
- Rule 21/1741 SA contain autonomous regulation functions, could these functions supplant conventional infrastructure upgrades?
- Distributed assets ≠ central power plants – is lower certainty of control acceptable?

What Will It Take?

- What would be necessary to facilitate acceptance of inverter functionalities by utilities?
- Common Smart Inverter Profile (CSIP) / 2030.5
- What processes/testing/standards/certifications can be put in place to create comfort with new technologies?
- How can distributed assets receive operational data from remote points on the grid?
- Safety and reliability are paramount drivers for means and methods, however technology is evolving rapidly and new technologies can offer improvements in these regards

Blockers

- The mandate to provide safety and reliability above all else, combined with confidence in legacy practices can result in utility conservatism

- Motivations for process improvement may not be apparent

- Smart inverters have all the capabilities but many are not aware of all that is available

- Standards and tariffs may prevent shared benefit solutions

Challenges the Same Everywhere

- Difficulties accessing loans especially from state-owned commercial banks owing to the reluctance of these banks to finance SMEs in general and to finance specific technologies perceived to be risky
- Lack of effective pricing mechanisms to monetize values of battery storage
- Lack of viable business models to cover the high upfront costs of battery storage
- Lack of policy and regulations on issues of access to the grid, environmental impacts and safety management, and battery recycling.
- https://www.energy-storage.news/news/world-bank-approves-china-loan-for-us750m-energy-storage-accelerator-progra

Takeaway Questions

- How can stakeholders gain comfort with existing and emerging functionalities?
- How can hosting capacity calculation take new functionalities into account?
- How can interconnection processes be improved to incorporate these developments and realize additional benefit streams?
- What needs to be tested and in what ways?
- What needs to be added to standards?

NREL
Transforming ENERGY

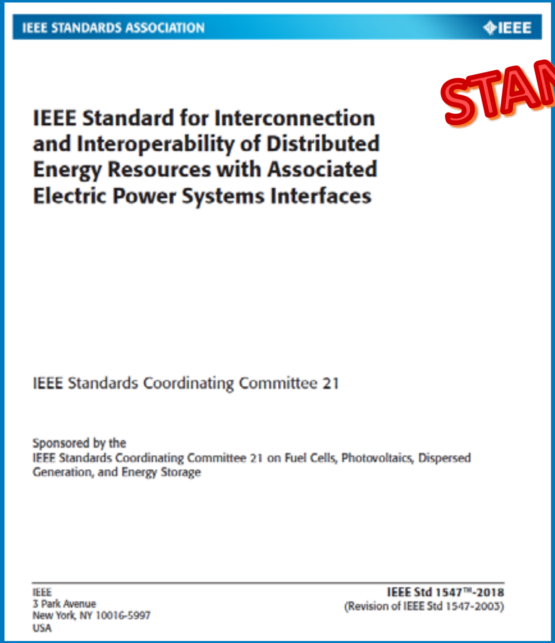
DER Interconnection Standard Development

Shazreen Meor Danial
Electrical Engineer/Project Lead

IEEE 1547-series Installation, Commissioning, Periodic Testing Sub-Working Group

P1547.1 Sub-Working Group Co-Lead

P1547.2 Sub-Working Group Lead


IEEE STANDARDS ASSOCIATION IEEE

IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

IEEE Standards Coordinating Committee 21

Sponsored by the
IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 1547™-2018
(Revision of IEEE Std 1547-2003)

IEEE 1547 Interconnection Standards Series

STANDARDS

IEEE 1547-2018
IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

IEEE P1547.1
[Draft] IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and Associated Interfaces

UL1741
Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With DERs

NEC NFPA 70e Articles
690 PV Systems
705 Interconnection
480 Storage Batteries
692 Fuel Cell
694 Wind Electric

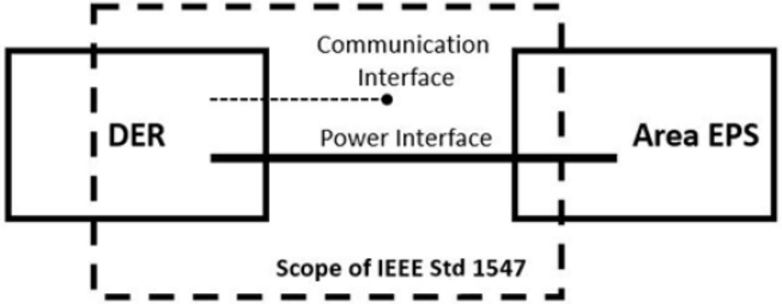
APPLICATION GUIDES

IEEE P1547.2
[Draft] IEEE Application Guide for IEEE Std 1547

IEEE P1547.9
[Draft] Guide to using IEEE 1547 for Interconnection of Energy Storage Distributed Energy Resources with Electric Power Systems

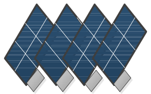
(upcoming)
IEEE P1547.3
Guide for Monitoring, Information Exchange, and Control of DER Interconnected with Electric Power Systems

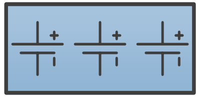
IEEE 1547-2018

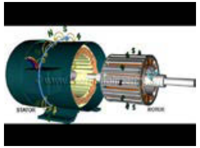


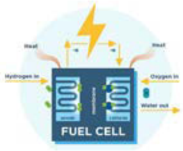
Technology neutral:

Solar
Wind
Fuel cell
Generators
Storage







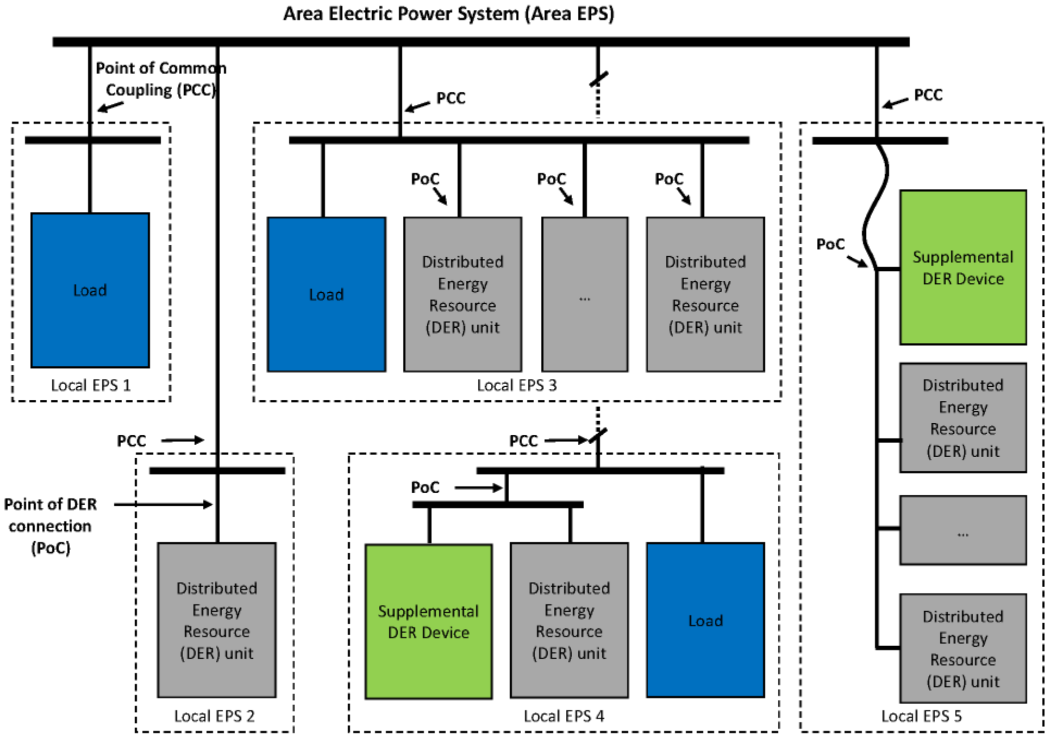


IEEE 1547-2018 standard establishes criteria and requirements for the interconnection and interoperability of DERs with EPS.

- Focuses on distribution and bulk system aspects.
- Specifications encompass the whole DER
- Can be used for equipment listing as well as plant-level verification
- Include both electrical power as well as interoperability/communications requirements

Included in IEEE 1547-2018…

- RPA determination
- Performance categories
- More coordinated operation under normal conditions
- Grid support under abnormal conditions
- Interoperability/communications
- New guidance on intentional islands
- Performance when reconnect
- Test requirements revised to address new capabilities
- Balance between needs for large and small installations.
- Others



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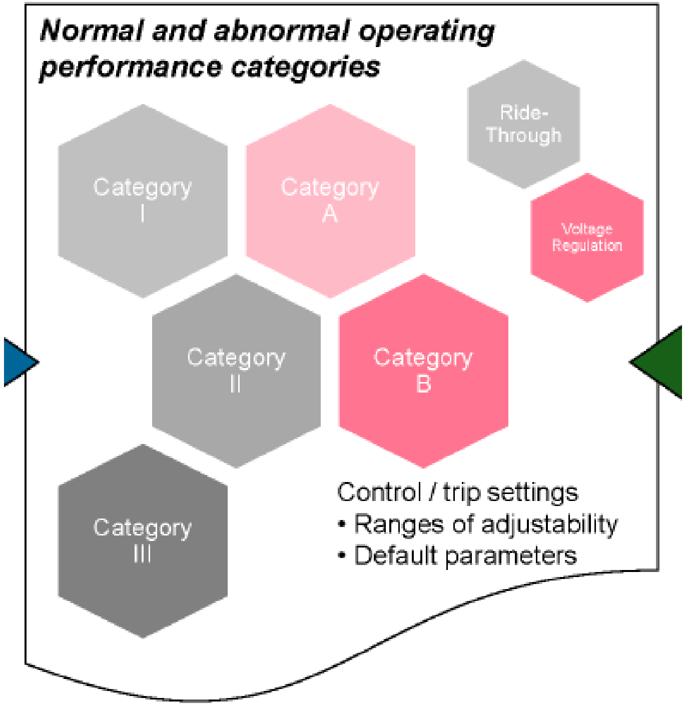

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- Others

Table 6—Voltage and reactive/active power control function requirements for DER normal operating performance categories

DER category	Category A	Category B
Voltage regulation by reactive power control		
Constant power factor mode	Mandatory	Mandatory
Voltage—reactive power mode[a]	Mandatory	Mandatory
Active power—reactive power mode[b]	Not required	Mandatory
Constant reactive power mode	Mandatory	Mandatory
Voltage and active power control		
Voltage—active power (volt-watt) mode	Not required	Mandatory

[a]Voltage-reactive power mode may also be commonly referred to as "volt-var" mode.
[b]Active power-reactive power mode may be commonly referred to as "watt-var" mode.

Included in IEEE 1547-2018…

- RPA determination
- Performance categories
- More coordinated operation under normal conditions
- Grid support under abnormal conditions
- Interoperability/communications
- New guidance on intentional islands
- Performance when reconnect
- Test requirements revised to address new capabilities
- Balance between needs for large and small installations.
- Others

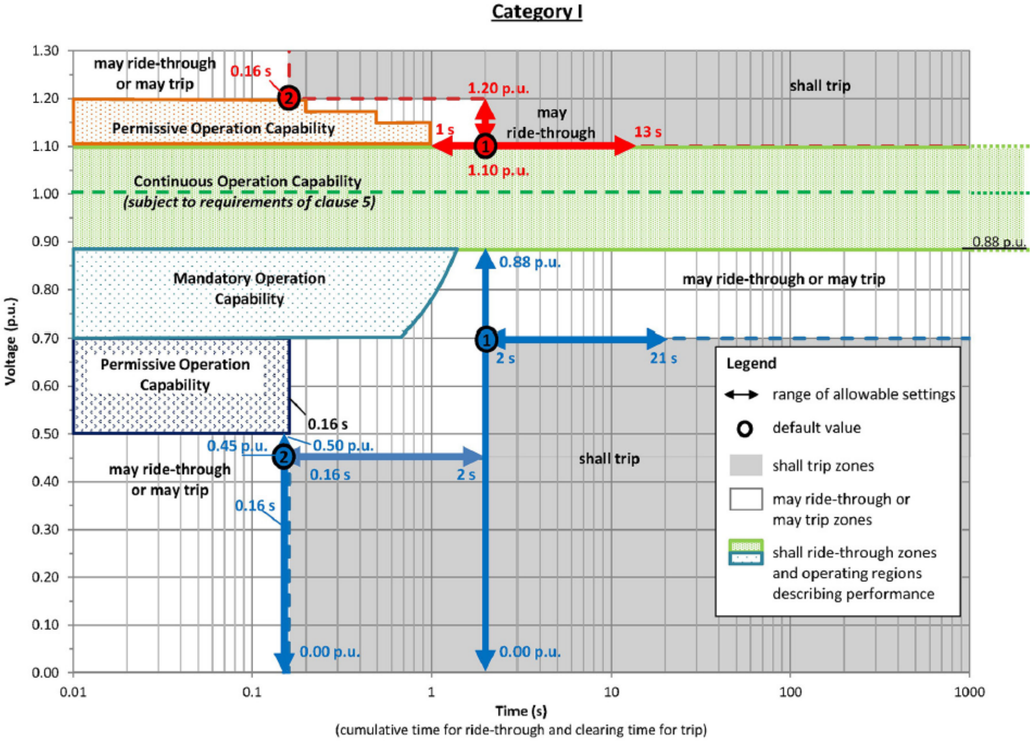

Figure H.7—DER response to abnormal voltages and voltage ride-through requirement for DER of abnormal operating performance Category I

Included in IEEE 1547-2018…

- RPA determination
- Performance categories
- More coordinated operation under normal conditions
- Grid support under abnormal conditions
- Interoperability/communications
- New guidance on intentional islands
- Performance when reconnect
- Test requirements revised to address new capabilities
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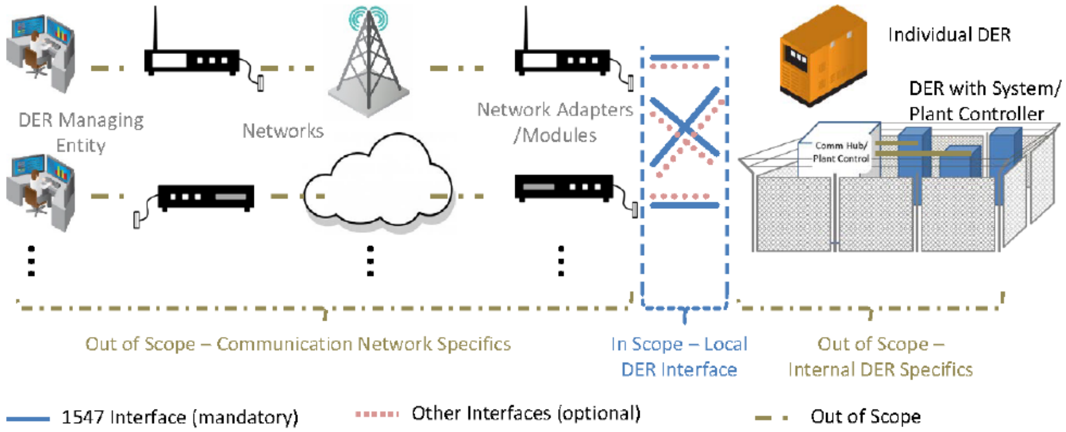
- Others



IEEE 1547.1 & Product Compliance Schedule

IEEE 1547-2018 published in April 2018

Q2/Q3/Q4 2019
IEEE-SA balloting, ballot resolution, ballot approval of P1547.1

Q1/Q2 2020
1547.1 Finalization and publication

Q3 2020 – Q4 2021
Inverter manufacturers update and recertify products to UL1741

Jan 2019

Jan 2020

Jan 2021

Jan 2022

Q3/Q4 2019
UL1741 begin revision draft to incorporate new 1547.1 and 1547

Q2/Q3 2020
UL1741 update published

Q4 2020 – Q4 2021
UL1741/IEEE1547-2018 compliant inverters expected to be available on market

IEEE 1547.1

Type Tests

- Response to voltage, frequency disturbance
- Power quality
- Unintentional islanding
- Voltage regulation
- Frequency support
- Fault conditions
- Active power limit
- Temperature stability
- Priority of responses
- Enter service, synchronization
- Interconnection integrity
- Prioritization

Production Tests

- Response to abnormal frequency, voltage

Design Evaluation, Installation Eval & Commissioning Tests

- DER Unit, DER System, DER Composite
- RPA at PCC & PoC
- Intentionally less prescriptive to allow for the wide variation of DER plants/installation and Area EPS operator procedures

Periodic Tests

- Reverification of impacted requirements when any hardware, software, firmware, setting change.

IEEE 1547 & 1547.1 are technology neutral and applicable to energy storage applications.

UL1741 – Interconnection equipment safety and performance certification.

» 1547.1 tests » Hardware construction » Safety & protection against risks of injury to persons » Rating, marking, installation

DER Unit, DER System, DER Composite

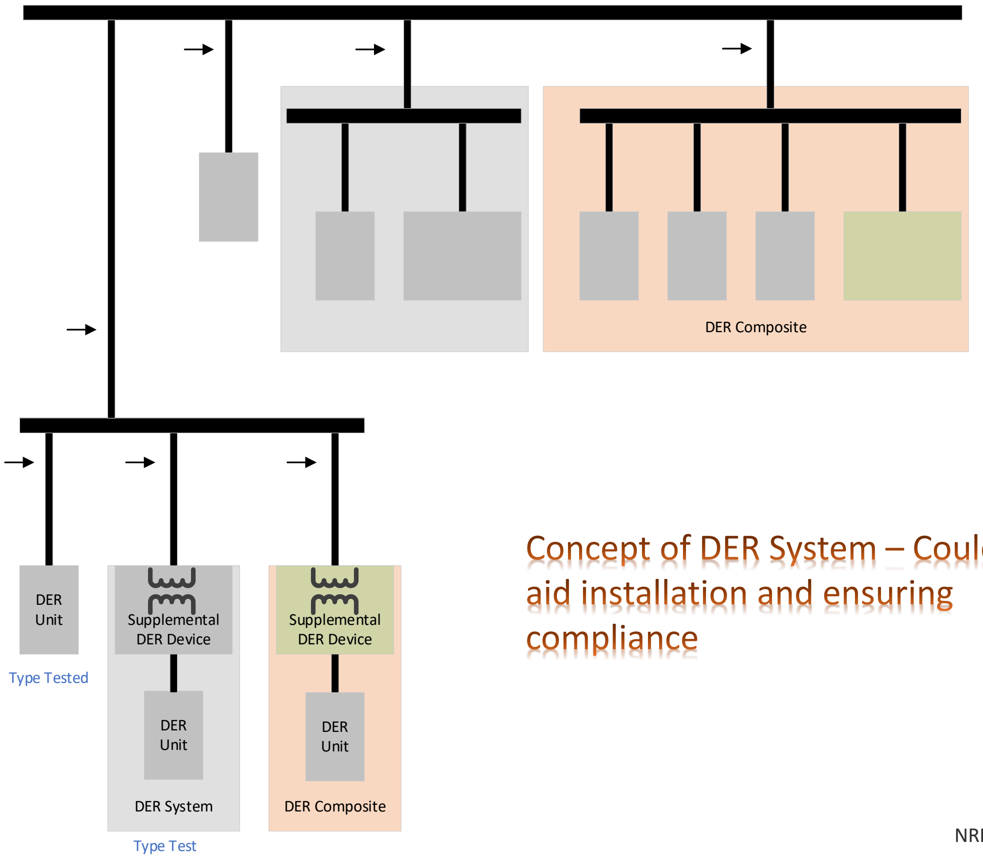
Definition of:

<u>DER Unit</u>: A fully compliant DER unit that does not require supplemental DER device to meet IEEE 1547 requirements.

<u>DER System</u>: A system that consist of DER unit(s) and supplemental DER device(s) that is type tested as a system and that, as a whole, is fully compliant with IEEE 1547.

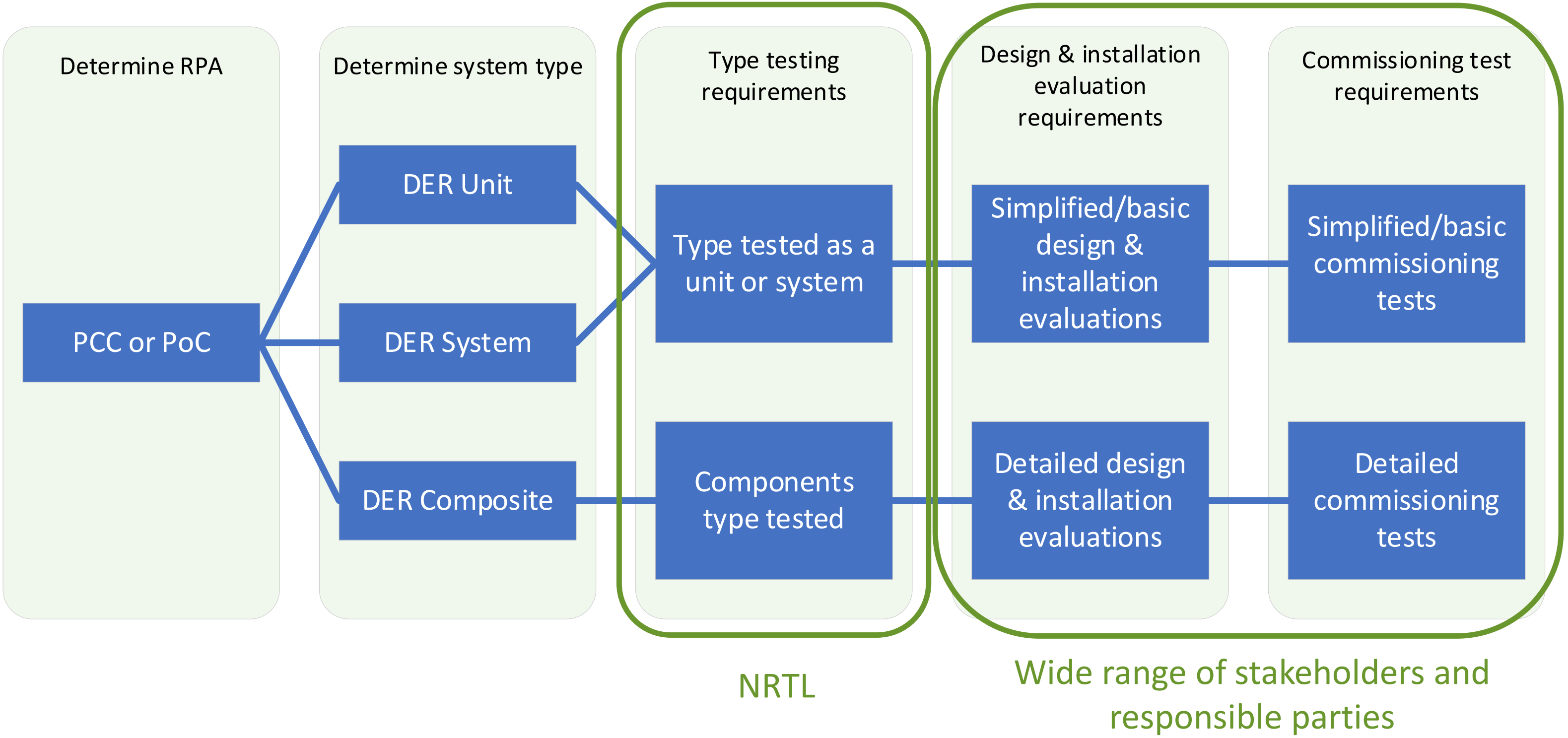
<u>DER Composite</u>: A system that consists of partially compliant DER components and supplemental DER device(s), and requires detailed design evaluation, installation evaluation, and commissioning tests to determine full compliance to IEEE 1547 requirements.

(in draft P1547.1)

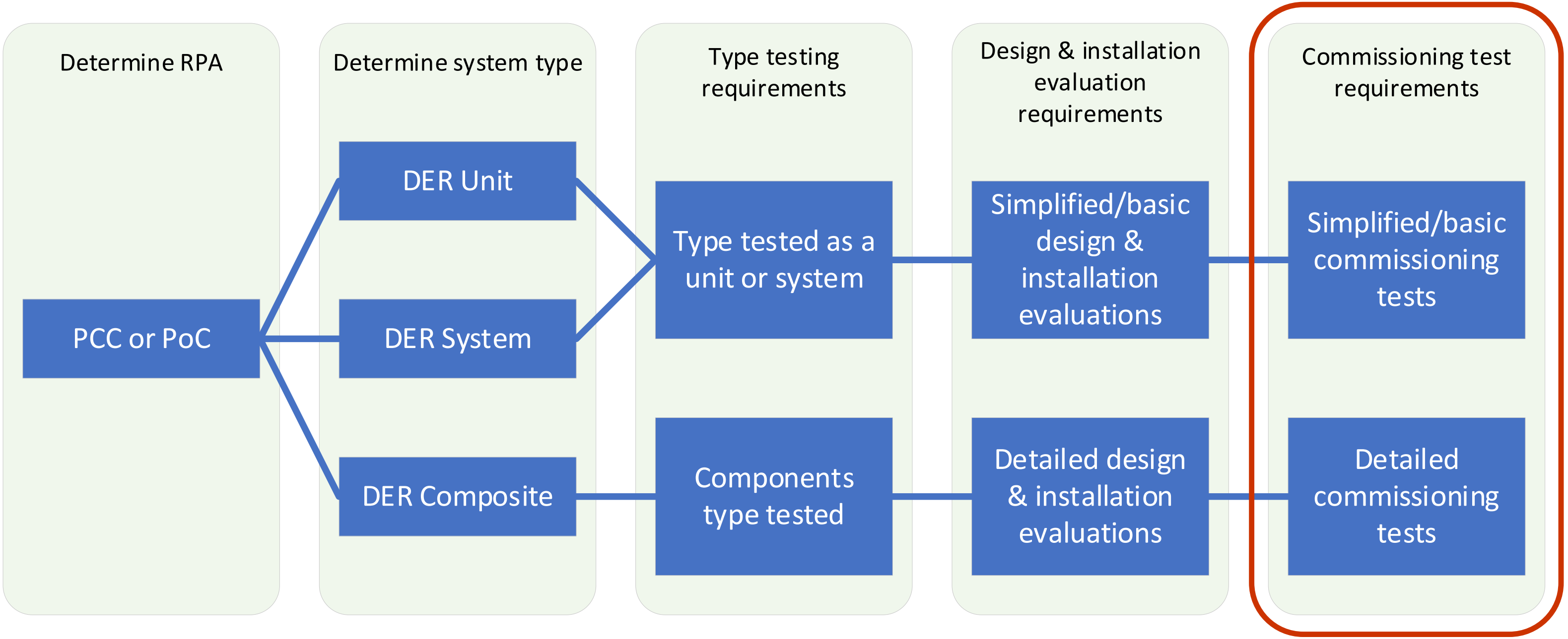


Concept of DER System – Could aid installation and ensuring compliance

Evaluation and Commissioning Process in P1547.1



Evaluation and Commissioning Process in P1547.1



Challenges: Complexity, feasibility, schedule, cost – Opportunity?

IEEE 1547.2

Application guide: [Draft] IEEE Application Guide for IEEE Std 1547

Schedule & current working group activities

- Monthly working group calls
- Biweekly/weekly sub-working group calls
- Working group meeting in Milwaukee, WI
- December 2020 – P1547.2 IEEE-SA initial sponsor ballot
- 2021 – IEEE 1547.2 publication

Active subgroup

Clauses 4.2 & 10.4 – Non- and Limited-Exporting DER
Clause 6.2 – Area EPS faults and open phase conditions
Clause 6 & Annex B.4 – T&D coordination
Clause 9 – DER on distribution secondary & spot networks
Clause 10 – Local DER interface
Clause 11 – Leading ICP practices
Clause 11.4 – Fault current characterization

IEEE 1547.9

<u>Application guide</u>: [Draft] Guide to using IEEE 1547 for Interconnection of Energy Storage DER with Electric Power Systems

Schedule & current working group activities

- Working group meeting every 3-4 months
- Re-occuring sub-working group calls
- Summer 2020 – WG complete draft

Active subgroup

Clause 4 (GI) – General interconnection

Clause 8 (ISL) – Islanding

SAFE – Safety, and liaison to ESSB

Clause 10 (INTEROP) – Interoperability

COOR – Industry coordination

Thoughts?

Challenges of implementing standards

Perspective from utilities, EPS operators, installers, system designer, system owner

Concept of DER System – how it could aid installation, commissioning

Opportunities in aiding commissioning tests of complex systems

System level testing in controlled environment, ie, labs

Hardware-in the-loop

Thank you

www.nrel.gov

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NREL Transforming ENERGY

IEEE STANDARDS ASSOCIATION IEEE

IEEE 1547 Conformity Assessment Program - Commissioning

DGIC Workshop – Overcoming Challenges for DER Interconnection:

Spotlight on Energy Storage

Washington, DC

July 29thth, 2019

Jason Allnutt
Conformity Assessment Specialist, ICAP

IEEE Standards Development Lifecycle

Conformity Assessment Program Benefits

- Increase Standards Adoption
- Provide Use-case examples for Standard's revision
- Creates market advantage for certified devices
- Gives end-user greater purchasing power
- Increases Interoperability
- Provides a point of contact for requirement inquires

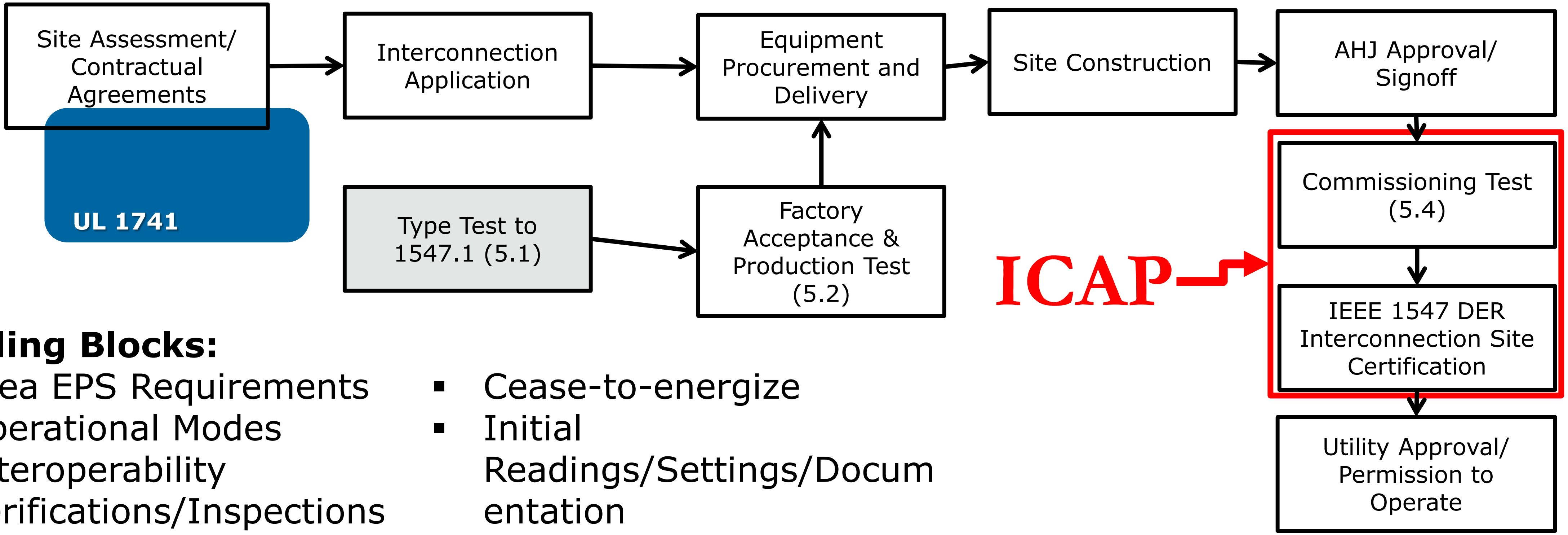
ICAP is a division of IEEE-SA that works closely with the Standards Working Group Liaisons to address the needs of standards development groups through conformity assessment.

ICAP Program Portfolio

- Phasor Measurement Unit (PMU) – IEEE C37.118
- IEEE Nuclear Equipment Standards – IEEE P60780 – 323
- PTP Power Profile – IEEE C37.238
- Camera Phone Image Quality (CPIQ)
- COMTRADE - IEEE C37.118
- Distributed Energy Interconnects – IEEE 1547/1547.1
- EV Charging – IEEE 2030.1.1
- Smart Energy Profile (SEP) 2.0 – IEEE 2030.5
- Sensors

The IEEE 1547 Commissioning CA Program

PROGRAM OBJECTIVE: Develop a Site Certification [process] with respect to DER Interconnection that Emphasizes All Essential Aspects of IEEE 1547/1547.1 over the life of the Interconnection.

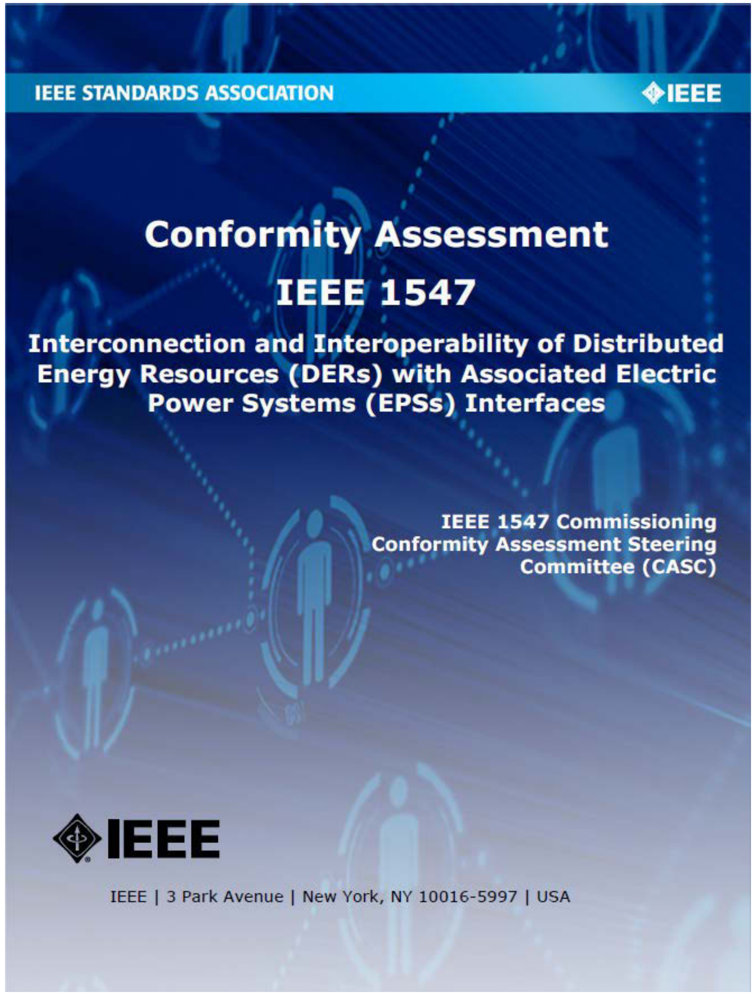


Building Blocks:

- Area EPS Requirements
- Operational Modes
- Interoperability
- Verifications/Inspections
- Unintentional Islanding
- Cease-to-energize
- Initial Readings/Settings/Documentation
- Commissioning Report

Conformity Assessment IEEE 1547

- Consensus approved Conformity Assessment Document for the commissioning of DER Interconnection to IEEE 1547.
- Developed within the IEEE 1547 Conformity Assessment Steering Committee – diverse membership of DER stakeholders
- Made freely available through IEEE-SA via IEEE Xplore
- Can be used to assess DER's of any type including mixed assets (i.e., Microgrids) – technology neutral
- Works in-sync with UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources., NOT in-lieu
- Living document with planned updates for inclusion of all clauses of recently published IEEE 1547-2018 and soon to be released IEEE 1547.1



NC Pilot - 6 MW Solar Installation

- Utility scale 6 MW Solar PV Installation with 3 three-phase inverters connected to Area EPS distribution network
- Commissioning of the interconnection for its compliance with IEEE 1547 in accordance with the approved Interconnection Agreement
- Multi-step process: 1) Document review, 2) On-site Inspection (de-engergized), 3) On-site System Performance Evaluation
- Documentation review and On-Site inspection found that “Enter Service” parameters of the inverters were not correctly applied and action was taken by the developer.
- Conformity Assessment was successfully completed Jun 2019

IN Pilot - Solar & Battery Installation

- Mixed Asset DER Site – 2.7 MW Solar PV, 4.588 MWH Energy Storage Capacity
- Assessment based on requirements in IEEE 1547a-2014 Clause 5.3 Interconnection Installation Evaluation and 5.4 Commissioning tests referenced in ICAP's IEEE 1547 CA Document
- Evaluation highlighted the need for clear documentation resources to ensure a successful commissioning of a mixed asset DER

Thank you

IEEE Conformity Assessment Program

http://standards.ieee.org/about/icap/index.html

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