Members-Only Interconnection Standards Technical Assistance Workshop

Danielle Sass Byrnett – NARUC
Michael Ingram, David Narang – NREL
Ravi Subramaniam - IEEE

July 17, 2022

Welcome!
Start jotting down on sticky notes:
What are you worried about re: DER interconnection?
(one thought per sticky)

Workshop Team

Facilitators

- Danielle Sass Byrnett – NARUC
- Michael Ingram, David Narang – NREL

Guest Speakers

- Ravi Subramaniam – IEEE
- Kerry Worthington – BCS for DOE EERE

You!

- Name, organization, <5 words on your exposure to DER interconnection issues to date

Workshop Goals

1. Increase awareness of existing materials & support to help state PUCs move forward on DER interconnection activities
2. Help members make connections to colleagues with similar challenges (and solutions!)
3. Support development of future interconnection improvement cohorts (technical assistance)

NARUC & NREL thank the U.S. DOE Energy Efficiency & Renewable Energy Office and National Institute of Standards and Technology for their support of this workshop.

Agenda for Today's Interconnection Workshop

Time	Topic	Activity
8:30am	Welcome & Level-Setting ● Introductions ● Objectives & agenda review	Journaling & Sharing ● What are you worried about re: DER interconnection?
9:10am	Existing Resources & Support ● When & how to approach updating stds ● Hands-on with NREL-developed guides ● IEEE resources	Walk-Through with Participant Questions ● Myth busting
10:25am	Break	
10:45am	Interconnection Challenges & Needs ● DOE's new I2X initiative ● Identify needs for technical assistance	Brainstorm & Prioritize ● Topics requiring assistance ● Activities that can be helpful
11:45am	Resources & Next Steps ● Available & forthcoming support	Update Your Calendars
12:00pm	Adjourn	

Today's Starting Points

Please jot down on sticky notes:
What are you worried about re: DER interconnection?
(one thought per sticky)

Process / Policy Challenges	Technical Challenges	Other

~20 mins

Agenda for Today's Interconnection Workshop

Time	Topic	Activity
8:30am	Welcome & Level-Setting ● Introductions ● Objectives & agenda review	Journaling & Sharing ● What are you worried about re: DER interconnection?
9:10am	**Existing Resources & Support** ● When & how to approach updating stds ● Hands-on with NREL-developed guides ● IEEE resources	**Walk-Through with Participant Questions** · Myth busting
10:25am	Break	
10:45am	Interconnection Challenges & Needs ● DOE's new I2X initiative ● Identify needs for technical assistance	Brainstorm & Prioritize ● Topics requiring assistance ● Activities that can be helpful
11:45am	Resources & Next Steps ● Available & forthcoming support	Update Your Calendars
12:00pm	Adjourn	

Interconnection Workshop

Michael Ingram and David Narang
NREL Power Systems Engineering Center

NARUC Interconnection Workshop
July 17, 2022

~20 mins

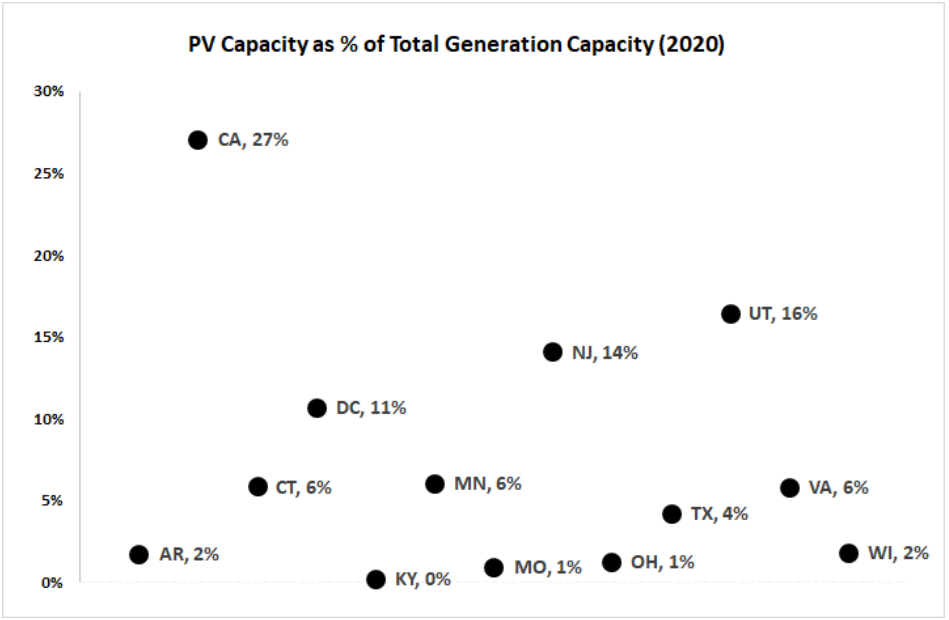
Acknowledgement

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Solar Energy Technologies Office Award Number 34808 and DOE SETO/WETO i2X project.

Context for DER Integration and Interconnection Landscape

~10 mins

2020 PV Installed Capacity and Forecast

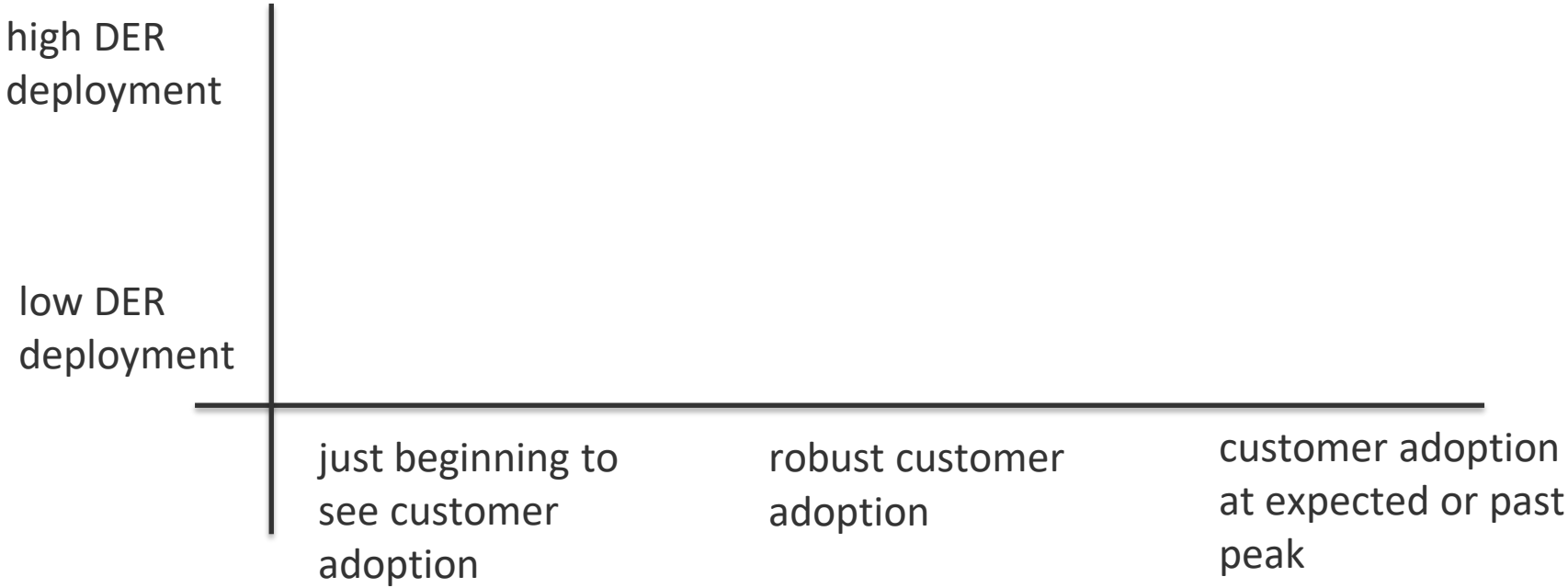


State	2020 PV Capacity (MWac)*	PV Capacity as % of Total	2032 Forecast (MWac)*
AR	286	1.7%	2,667
CA	22,531	27.1%	56,244
CT	662	5.9%	2,669
DC	93	10.7%	580
KY	45	0.2%	2,522
MN	1,181	6.0%	6,150
MO	229	1.0%	2,442
NJ	2,688	14.1%	6,949
OH	377	1.3%	11,626
TX	5,839	4.2%	44,174
UT	1,660	16.5%	4,226
VA	1,733	5.8%	14,599
WI	332	1.8%	6,971

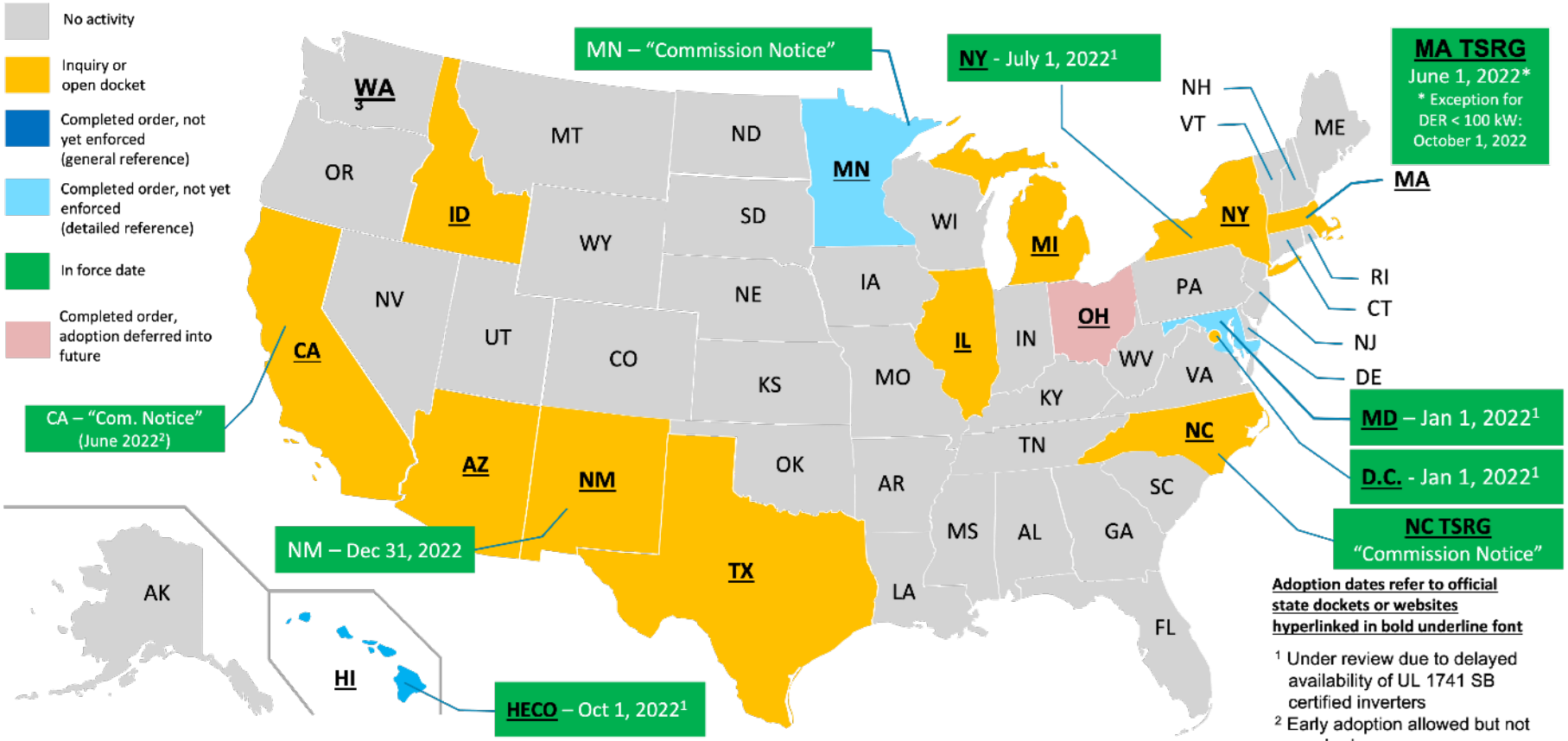
data sources: Wood Mackenzie/Solar Energy Industries Association US Solar Market Insight 2021 Year in review full report and U.S. Energy Information Administration https://www.eia.gov/electricity/data.php#summary

**Original data given in MWdc – converted to AC using 15% derate*

Group Activity
1: Where would you place yourself right now?
2: When do expect to reach the top right?



State Activity on IEEE Std 1547-2018



Adoption dates refer to official state dockets or websites hyperlinked in bold underline font

[1] Under review due to delayed availability of UL 1741 SB certified inverters

[2] Early adoption allowed but not required

[3] Reference to "latest" IEEE 1547

source: https://sagroups.ieee.org/scc21/standards/1547rev/

Considerations for Developing Interconnection Rules Within a Broader DER Integration Framework

~20 mins

A Guide to Updating Interconnection Rules and Incorporating IEEE Standard 1547

Michael Ingram, Akanksha Bhat, and David Narang

National Renewable Energy Laboratory

www.nrel.gov/grid/ieee-standard-1547/guide-to-updating-interconnection-rules.html

Recommended Approach to DER Interconnection Rule Update

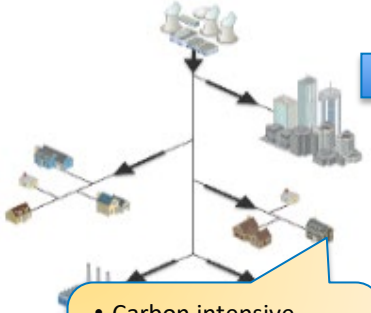
1. **(Preplanning)**
   Determining the context, stakeholders, and major drivers

- **Internal motivations**
  (e.g., reason for regulatory action, technical, market, policy)
- **Broader context**
  (e.g., distribution system planning)
- **Stakeholders and roles**
  (key decision makers)
- **Structure of the interconnection process** (e.g., performance indicators, data collection, process map, and analysis)
- **Procedural timeline**
- **Related/relevant procedures**

Develop an Internal Vision Aligned with Broader Context

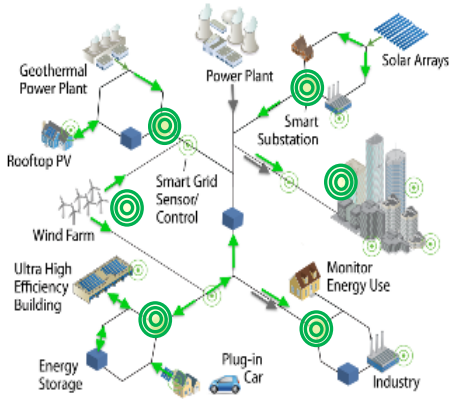
DER interconnection must be considered within the broader context of DER integration which includes national energy policy goals, market trends, technical requirements and stakeholder viewpoints and other efforts such as grid modernization.

Current Power System



- Carbon intensive
- Large generation
- Central control
- Highly regulated.

Future Power Systems



DRIVERS

- Increased variable generation
- More bidirectional flow at distribution level
- Increased number of smart/active devices
- Evolving institutional environment.

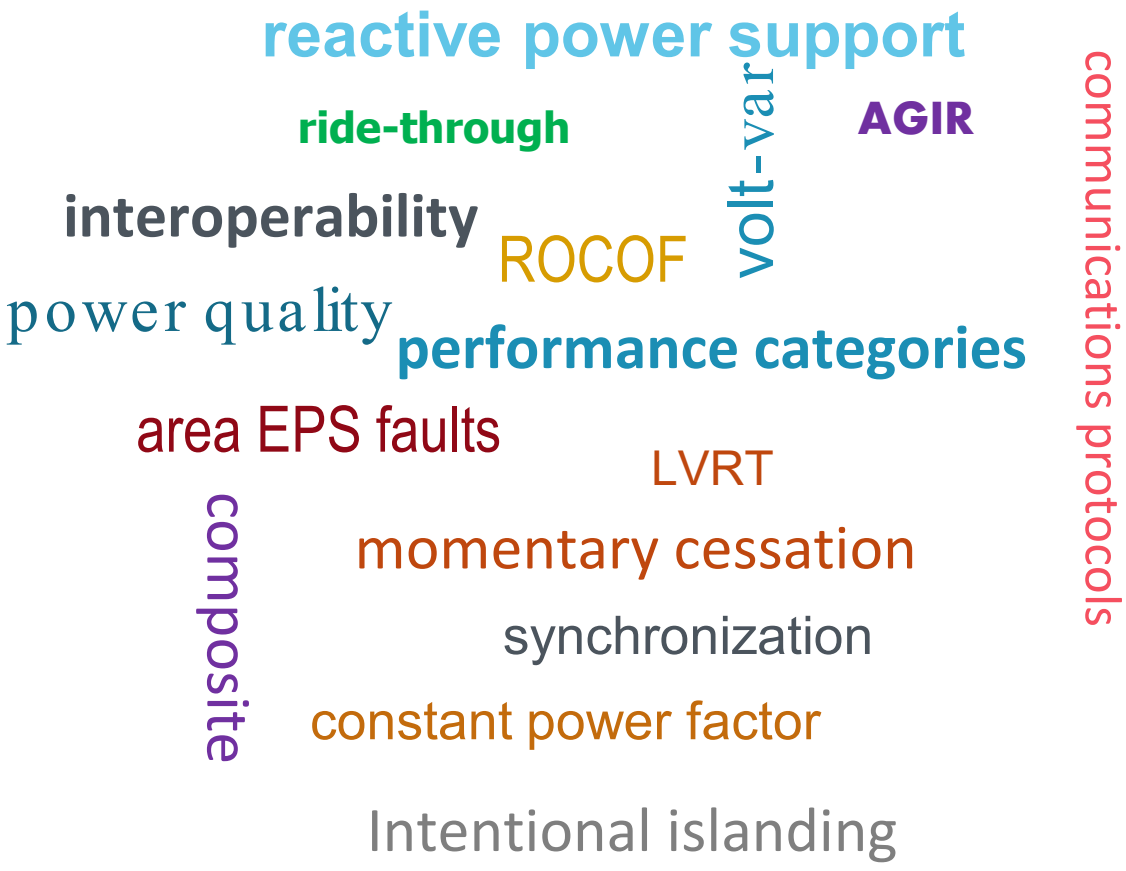
Our evolving power system context:

- New energy technologies and services
- Increasing penetrations of variable renewables on the grid
- New communications and controls (e.g., smart grids)
- Electrification of transportation
- Integrating distributed energy storage
- A modern grid needs increased system flexibility.
- Updated standards—e.g., IEEE Std 1547-2018, IEEE Std 2800 (distributed energy resources [DERs] as grid assets).

Slide courtesy of Dr. Ben Kroposki, NREL

Determine how you want to use DER in early stages

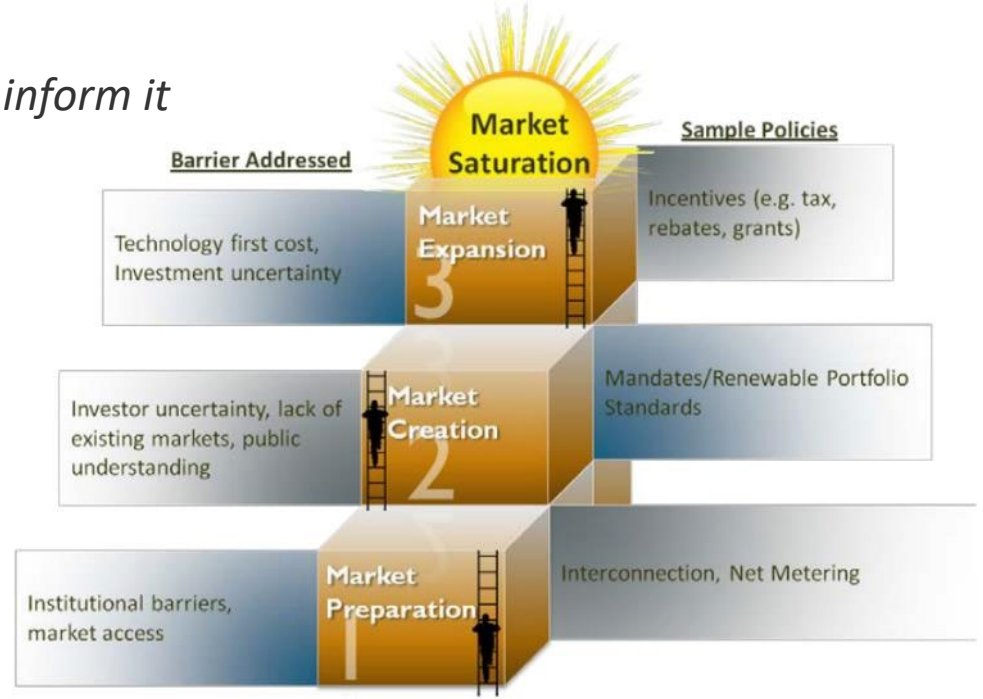
Technical aspects of DER interconnection regulations are directly linked to the intended use of DER capabilities. Therefore, the intended use should be clearly defined PRIOR to developing technical interconnection aspects.



Coordinate Requirements With Policy and DER Deployment

Regulators may not set policy but should inform it

Regulators should consider developing technical interconnection requirements in coordination with a "policy stacking" framework sensitive to DER deployment maturity levels *(needs early and continued coordination with the other entities responsible for policy setting and market development)*



Example generalized policy stack for DER

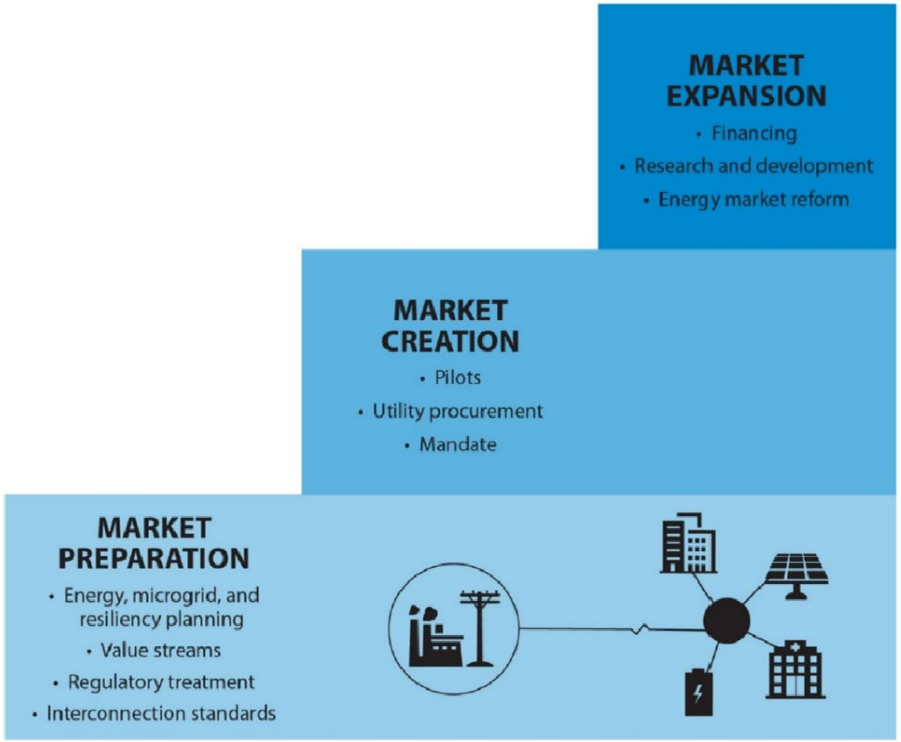
Image source: Krasko and Doris, 2012

References:

Strategic Sequencing for State Distributed PV Policies: A Quantitative Analysis of Policy Impacts and Interactions, V.A. Krasko and E. Doris, 2012
http://www.osti.gov/servlets/purl/1054826/
"Policy Building Blocks: Helping Policymakers Determine Policy Staging for the Development of Distributed PV Markets", E. Doris, 2012,
https://www.nrel.gov/docs/fy12osti/54801.pdf

Consider all Types of DER Desired/Planned/Market-Indicated

Different types of DER will likely require specific consideration of their policy stack, market adoption characteristics, intended use, and technical requirements.



Example policy stack for microgrids

Image source: Cook, 2018

References:

- *"Check the Stack: An Enabling Framework for Resilient Microgrids", Cook et. al., 2018, https://www.nrel.gov/docs/fy19osti/71594.pdf*

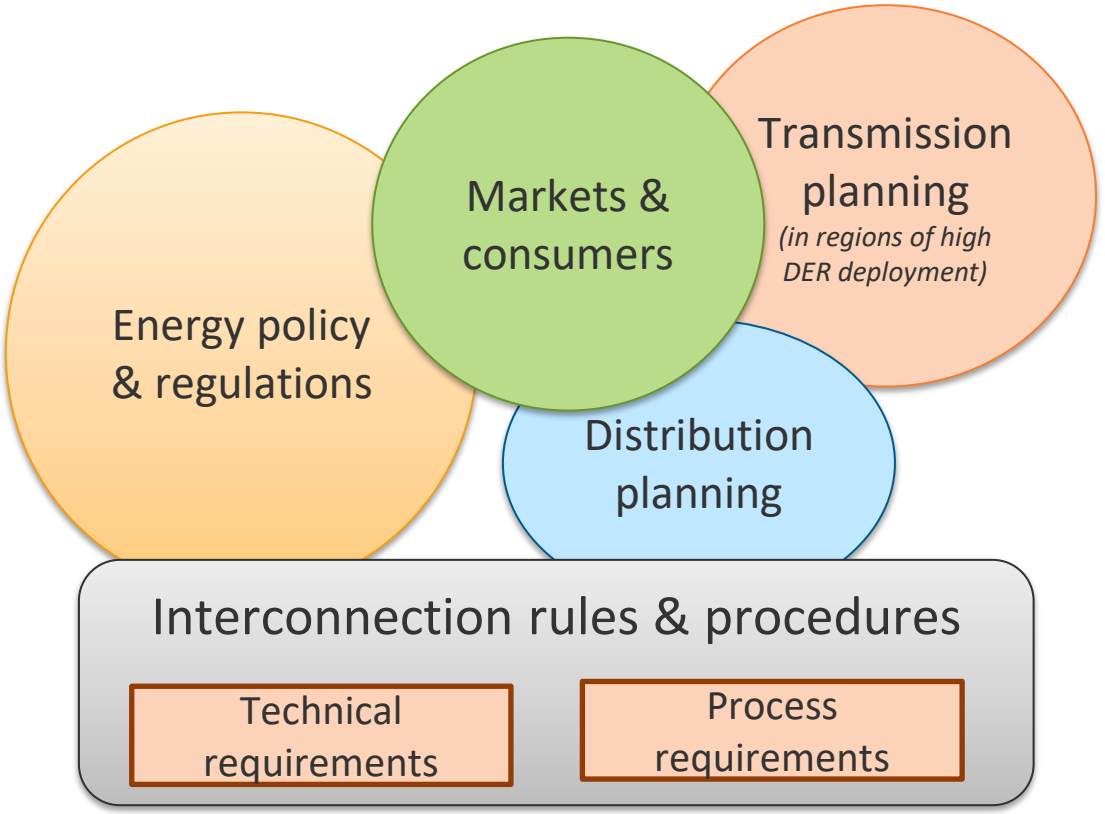
Recommended Approach to DER Interconnection Rule Update

2. Developing the DER interconnection rule

- **Broad goals for technical requirements**
  (e.g., safety, reliability, power quality, protection, affordability, markets, regulatory compliance)
- **IEEE Std 1547-specific**
  (e.g., reactive power support, fault ride-through, interoperability, intentional islanding, energy storage)
- **Jurisdiction/utility-specific**
  (e.g., metering, protection)
- **Other coordination required**
  (e.g., bulk power sys.)

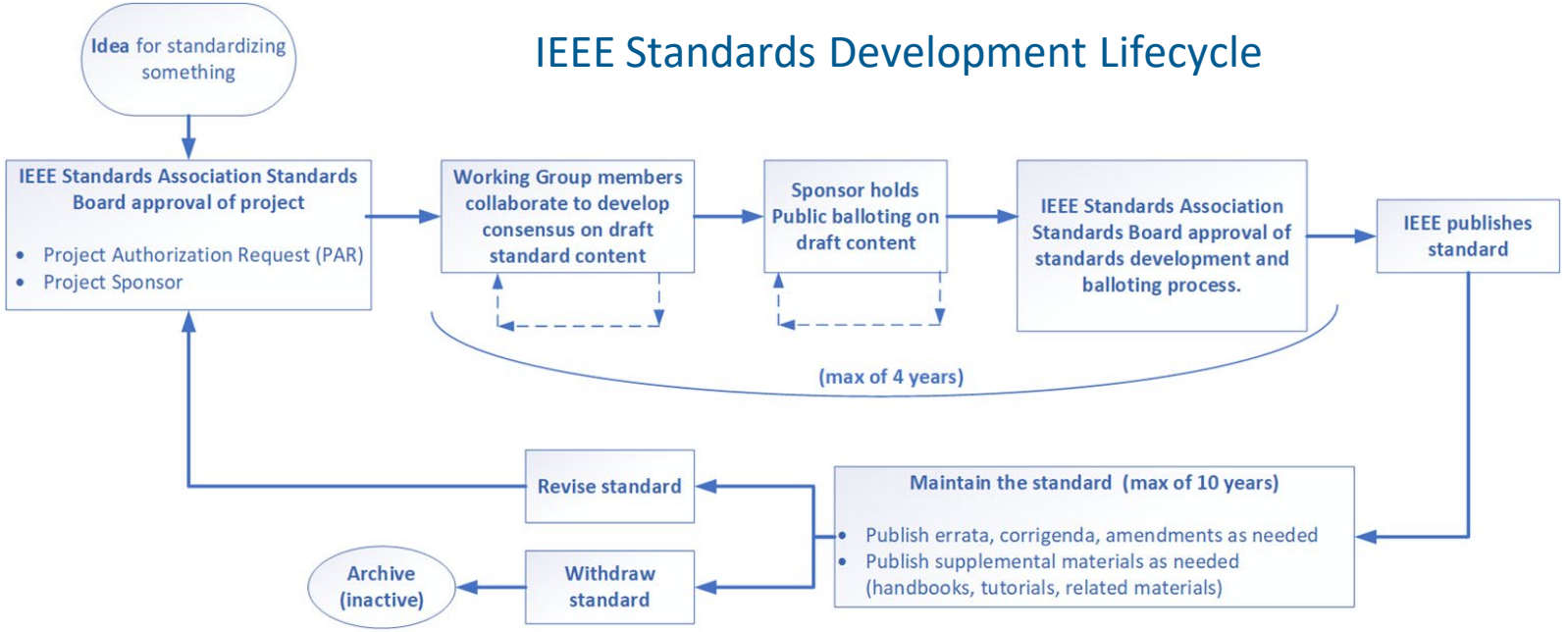
Use of DER Capabilities Evolves over Time

DER interconnection process and technical issues often overlap and are not easily segregated, and regulations must consider and evaluate issues for both types of topics.



References:

Rely on the Latest National Standards



Source: based on https://standards.ieee.org/develop/develop-standards/process.html

Rely on the latest (most up-to-date) national technical standards.

e.g.,

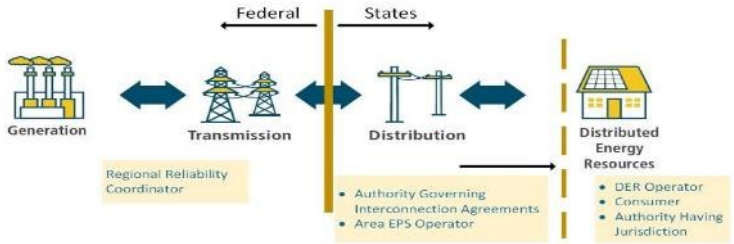
- IEEE Std 1547-2018
- IEEE Std 2800-2022

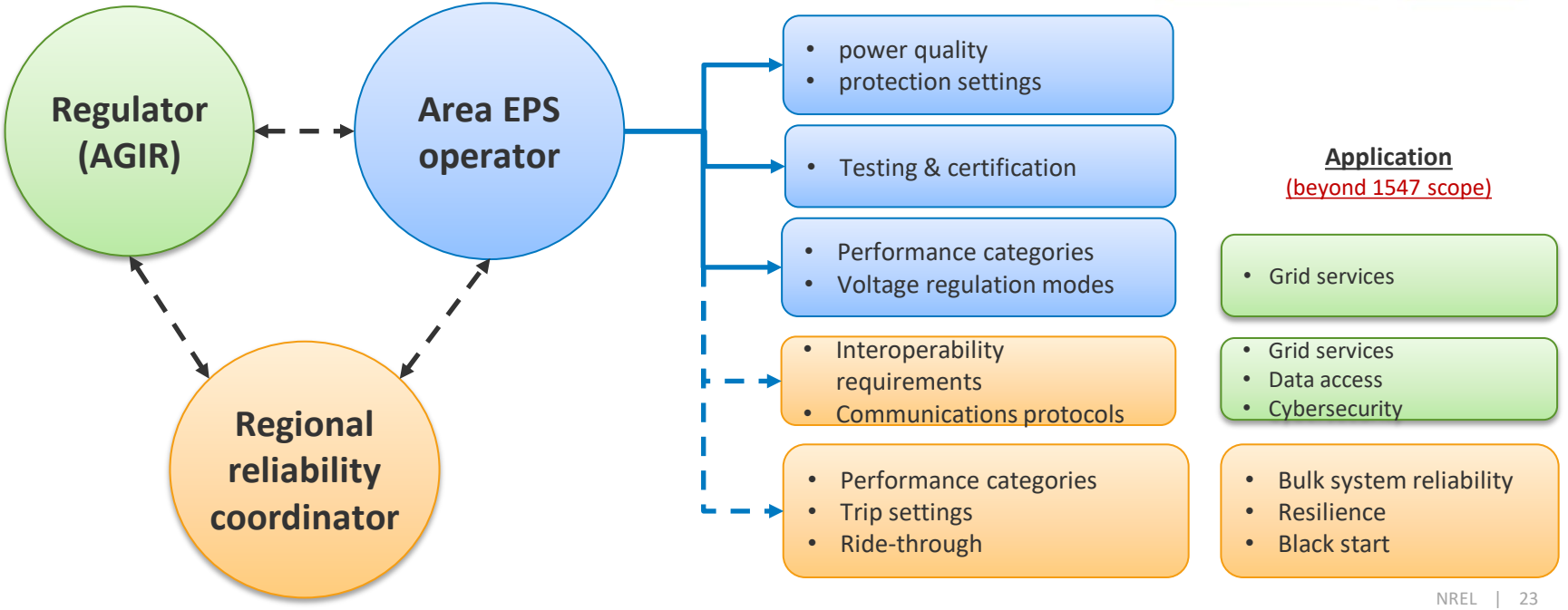
The National Association of Regulatory Utility Commissioners (NARUC) resolution in February 2020 recommends state commissions act to adopt and implement the revised standard. *https://pubs.naruc.org/pub/E86EF74B-155D-0A36-3138-B1A08D20E52B*

Ref: IEEE standards process overview: https://standards.ieee.org/develop/index.html

Coordination is Required for Utilization of Certain DER Capabilities

Closer and earlier coordination is required with relevant stakeholders for using and applying capabilities that affect other functions/across jurisdictional boundaries





Recommended Approach to DER Interconnection Rule Update

1. **(Preplanning)** Determining the context, stakeholders, and major drivers

2. Developing the DER interconnection rule

3. Maintaining and revising

- **Internal motivations** (e.g., reason for regulatory action, technical, market, policy)
- **Broader context** (e.g., distribution system planning)
- **Stakeholders and roles** (key decision makers)
- **Structure of the interconnection process** (e.g., performance indicators, data collection, process map, and analysis)
- **Procedural timeline**
- **Related/relevant procedures**

- **Broad goals for technical requirements** (e.g., safety, reliability, power quality, protection, affordability, markets, regulatory compliance)
- **IEEE Std 1547-specific** (e.g., reactive power support, fault ride-through, interoperability, intentional islanding, energy storage)
- **Jurisdiction/utility-specific** (e.g., metering, protection)
- **Other coordination required** (e.g., bulk power sys.)

- **Triggers for updates**
- **Scope of update**
- **Maintainability of the rule**

Suggested Reading for Regulators

- Interconnection Rule Update
- Setting the Scope of the Interconnection Rule
- Considerations for Technical Requirements
- Considerations for Use of IEEE Std. 1547-2018

https://www.nrel.gov/grid/ieee-standard-1547/curriculum-agirs.html

Live walk-through of existing educational resources

https://www.nrel.gov/grid/ieee-standard-1547/curriculum-agirs.html

~30 mins

IEEE Std 1547-2018 Decision Matrix

Topic/1547 Clause	AEPSO	DERO	RRC	AGIR
General requirements (Clause 4)	Lead	Coord.	Limited Consult	
Enabling/utilization of reactive power and voltage/power control capabilities (Clause 5)	Lead	Coord.		Consult? Based on policy and market goals? enabling voltage regulation, specification of which capabilities, grid services desired?
DER response to area EPS abnormal conditions (Clause 6 & 7)	Lead	Coord.	Consult (BPS req.)	Consult? Based on policy and market goals? Specification of "robustness" of response. Cat I, II, III
Islanding	Lead	Coord.		Consult? Based on policy and market goals, stakeholder input, microgrid application and uses.
Enabling/Utilization of interoperability capabilities (Clause 10)	Lead	Coord.	Consult? (BPS req.)	Consult? Based on policy and market goals, stakeholder input, RRC situational requirements (if noted).
Test and Verification*	Lead	Lead		

AEPSO (area EPS operator), DERO (DER operator), RRC (regional reliability coordinator),
AGIR (authority governing interconnection requirements, typ. regulator), OEM (equipment manufacturer, e.g., inverter)
*type testing is led by the OEM

Reflections

Myth Busting!
What worries can you let go?

Highlights of other public education efforts

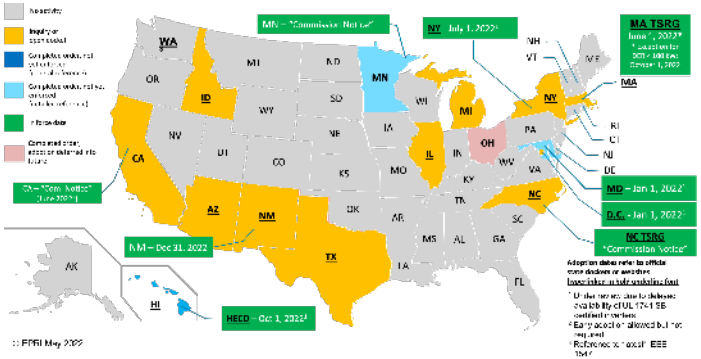
- EPRI U:
  Public (with free EPRI account):
  https://www.epri.com/#/epri-u/courseslang=en-US

- IREC
  - Publications: https://irecusa.org/blog/tag/ieee-1547/
  - Informal inverter manufacturer discussion forum (FIIGI, typ. weekly)

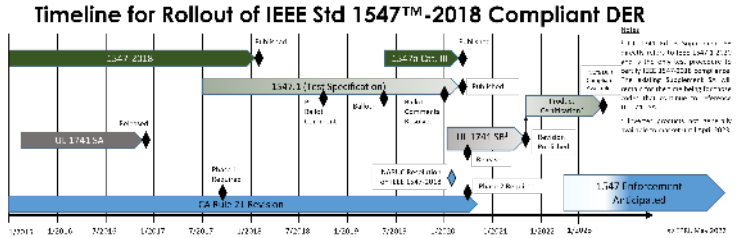
- others?

IEEE Standards Coordinating Committee 21 (SCC21) Resources and Outreach

- **Public web site on IEEE Std 1547**
  http://sites.ieee.org/sagroups-scc21/standards/1547rev/
  - Discount/free copies of the standard for select stakeholders (e.g., regulators)
  - Education and training/reading material – papers, webinars
  - "approved" presentation content for SMEs
  - Catalog of ISO/RTO T&D coordination activities
  - State activity map (maintained ~ quarterly)
  - Inverter rollout timeline ("regularly" maintained)
- **Informal industry/stakeholder coordination calls (quarterly)**
- **Coordination with other IEEE societies, committees & related standards (constant)**

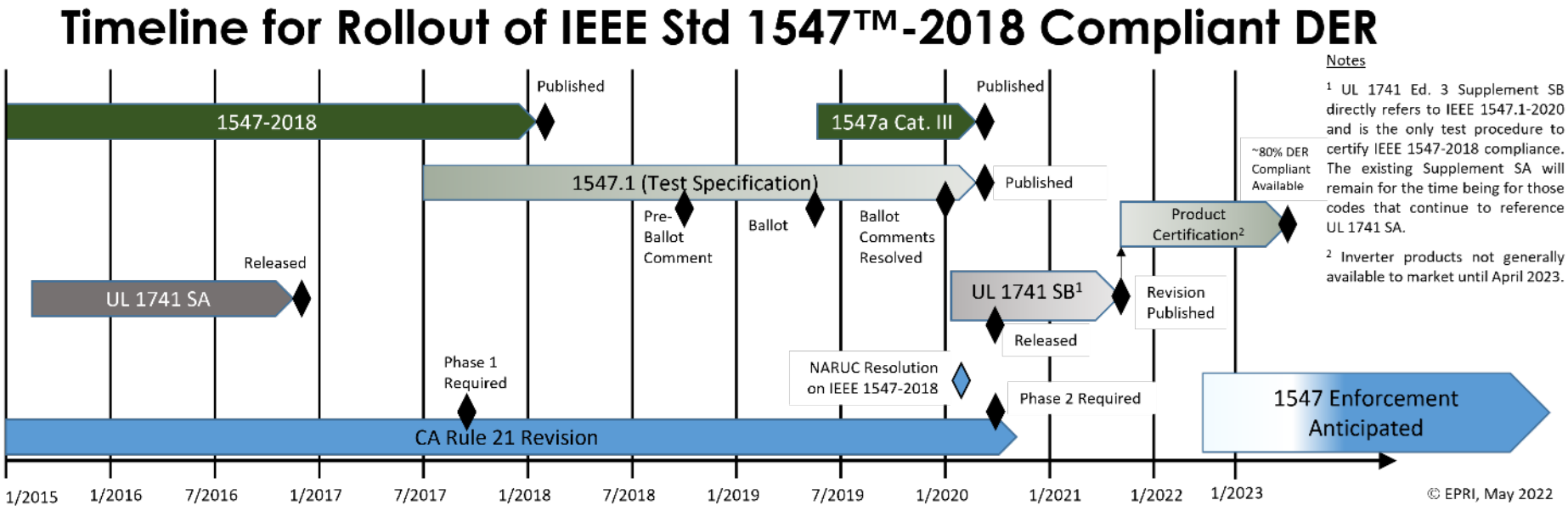


State activity map



Inverter rollout timeline

IEEE Std 1547-2018 Compliant DER Rollout Timeline



Source: SCC21, image credit EPRI

Recurring Reliability Issues with IBRs

- Unexpected tripping, cessation of active power, oscillations, etc.
- Mis-application of IEEE 1547 standard for Transmission connected resources
- Analysis found **opportunity for standardization** of IBR performance to maintain grid reliability

Source: NERC, 2017-2022

Slide courtesy of IEEE 2800 leadership team

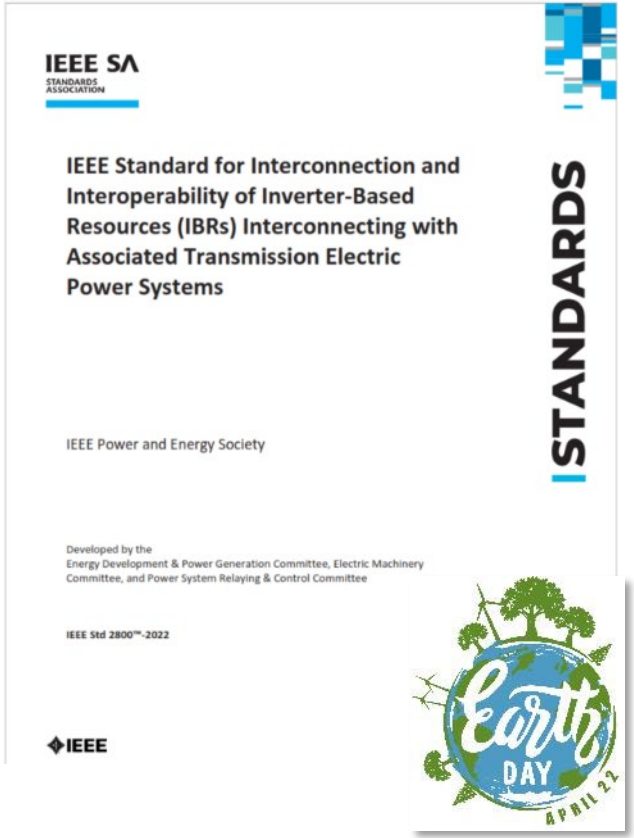
IEEE PES Power & Energy Society®

IEEE

Summary of IEEE 2800 Standard

- ❑ The standard **harmonizes** Interconnection Requirements for Large Solar, Wind and Storage Plants
- ❑ It is a **consensus-based** standard developed by over ~175 Working Group participants from utilities, system operators, transmission planners, & OEMs over 2 years
- ❑ It has successfully passed the IEEE SA ballot among 466 SA balloters **(>94% approval**, >90% response rate)
- ❑ **Published on April 22, 2022 (Earth Day)**

More Info at https://sagroups.ieee.org/2800/



Slide courtesy of IEEE 2800 leadership team

Available from IEEE at https://standards.ieee.org/project/2800.html and via IEEExplore: https://ieeexplore.ieee.org/document/9762253/

IEEE PES Power & Energy Society®

IEEE

Guest speaker

- Ravi Subramaniam, IEEE

Agenda for Today's Interconnection Workshop

Time	Topic	Activity
8:30am	Welcome & Level-Setting ● Introductions ● Objectives & agenda review	Journaling & Sharing ● What are you worried about re: DER interconnection?
9:10am	Existing Resources & Support ● When & how to approach updating stds ● Hands-on with NREL-developed guides ● IEEE resources	Walk-Through with Participant Questions · Myth busting
10:25am	Break	
10:45am	**Interconnection Challenges & Needs** ● DOE's new I2X initiative ● Identify needs for technical assistance	**Brainstorm & Prioritize** ● Topics requiring assistance ● Activities that can be helpful
11:45am	Resources & Next Steps ● Available & forthcoming support	Update Your Calendars
12:00pm	Adjourn	

Interconnection Challenges & Needs

- DOE's new I2X initiative
- Identify needs for future / additional technical assistance

~60 mins

INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

Selected Slides from Launch Webinar

June 7th, 2022

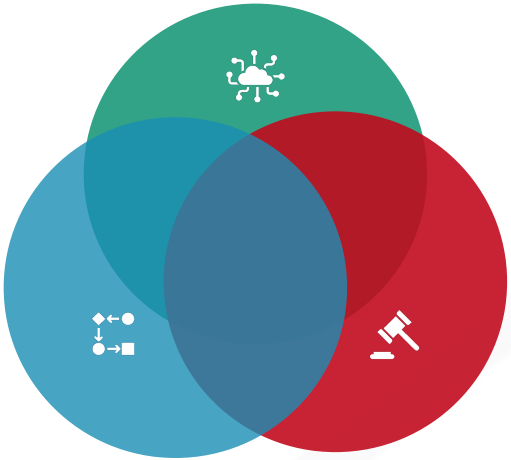
an EERE collaboration between SETO & WETO

~15 mins

Program Organization & Focus Areas

DOE Solar & Wind Energy Technologies Offices of EERE	→	Program Owner & Lead, lead facilitator
Pacific Northwest National Laboratory (PNNL)	→	Lab lead, project management, stakeholder engagement, TA, communications
Lawrence Berkley National Laboratory (LBNL)	→	TA – transmission, data collection & analysis
National Renewable Energy Laboratory (NREL)	→	TA – distribution, data collection & analysis

Prior Workshop Feedback on Interconnection Challenges



Technology & Engineering

- Complex grid reliability impact assessments of intermittent generation assets
- Outpaced Transmission planning and expansion by high incentives for renewables
- Fragmented Transmission & Distribution institutional coordination

Administrative Process

- Insufficient human resources and capabilities to manage long queues
- Unfair cost allocations triggered by unpredictable grid networks upgrades
- Opaque grid networks data and modeling informational asymmetries

Markets & Regulation

- Dizzying rules and regulations for interconnecting to distribution networks
- Misaligned utility models for private ownership of distributed generation
- Insufficient regulatory oversight of queue management and compliance

The i2X Mission

To enable the **simpler**, **faster**, and **fairer** interconnection of solar and wind energy resources all while boosting **reliability**, **resiliency**, and **security** of our electric grid.

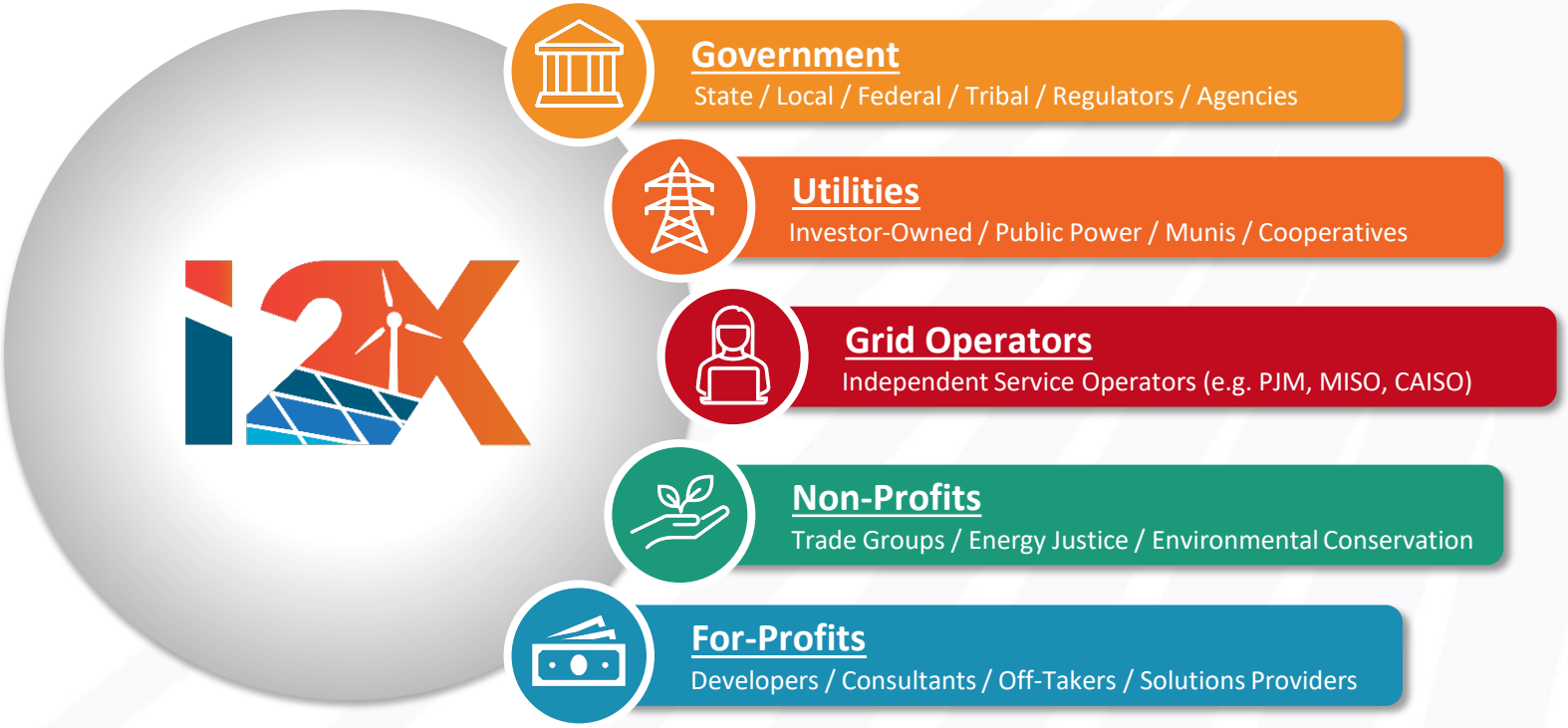
Stakeholder Engagement

Data Collection and Transparency

5-Year Strategic Roadmap

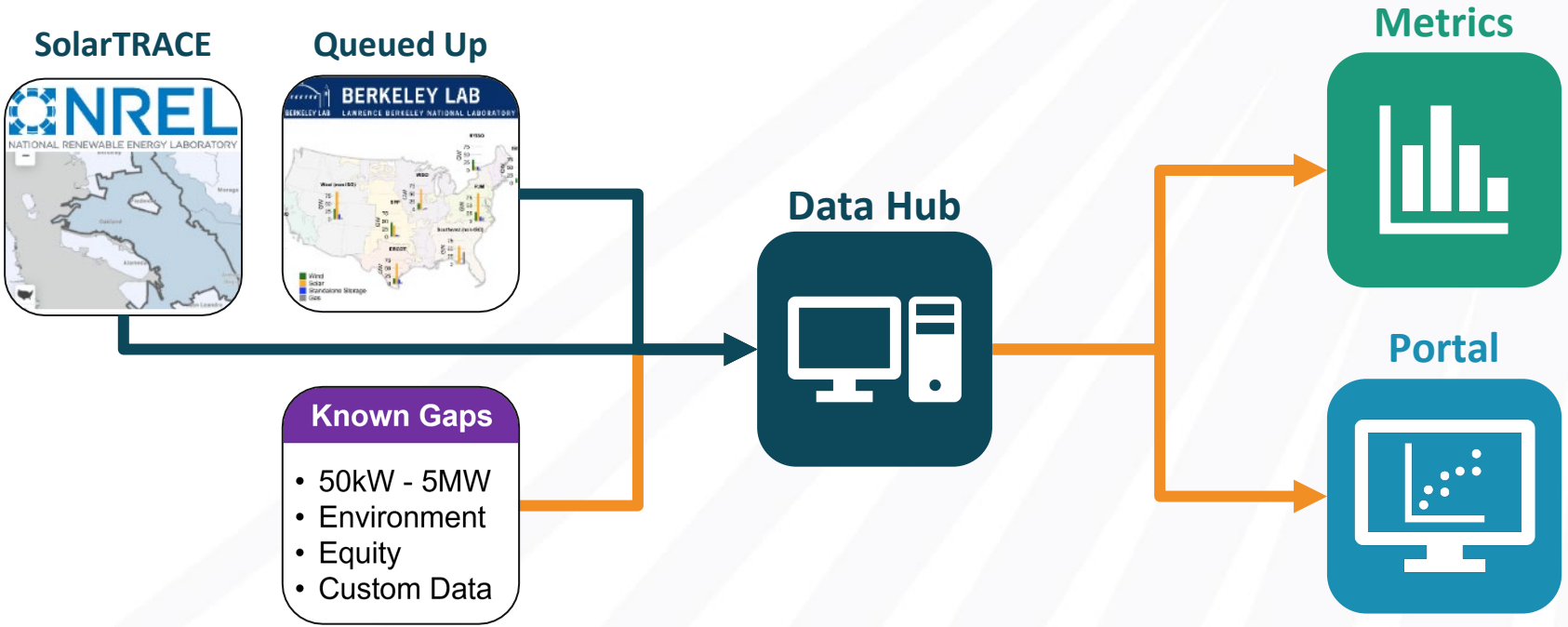
Technical Assistance

Stakeholder Diversity

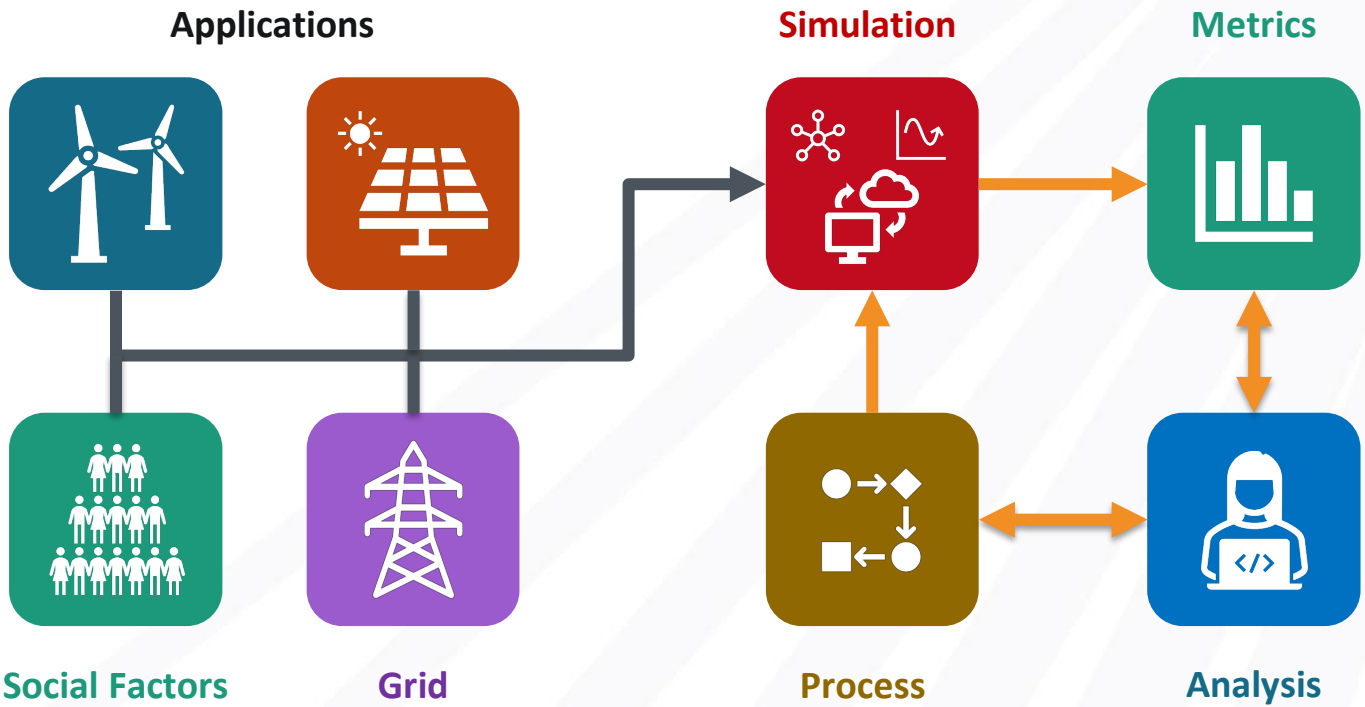


Work Focus Areas

Filling Data Gaps to Support New Metrics



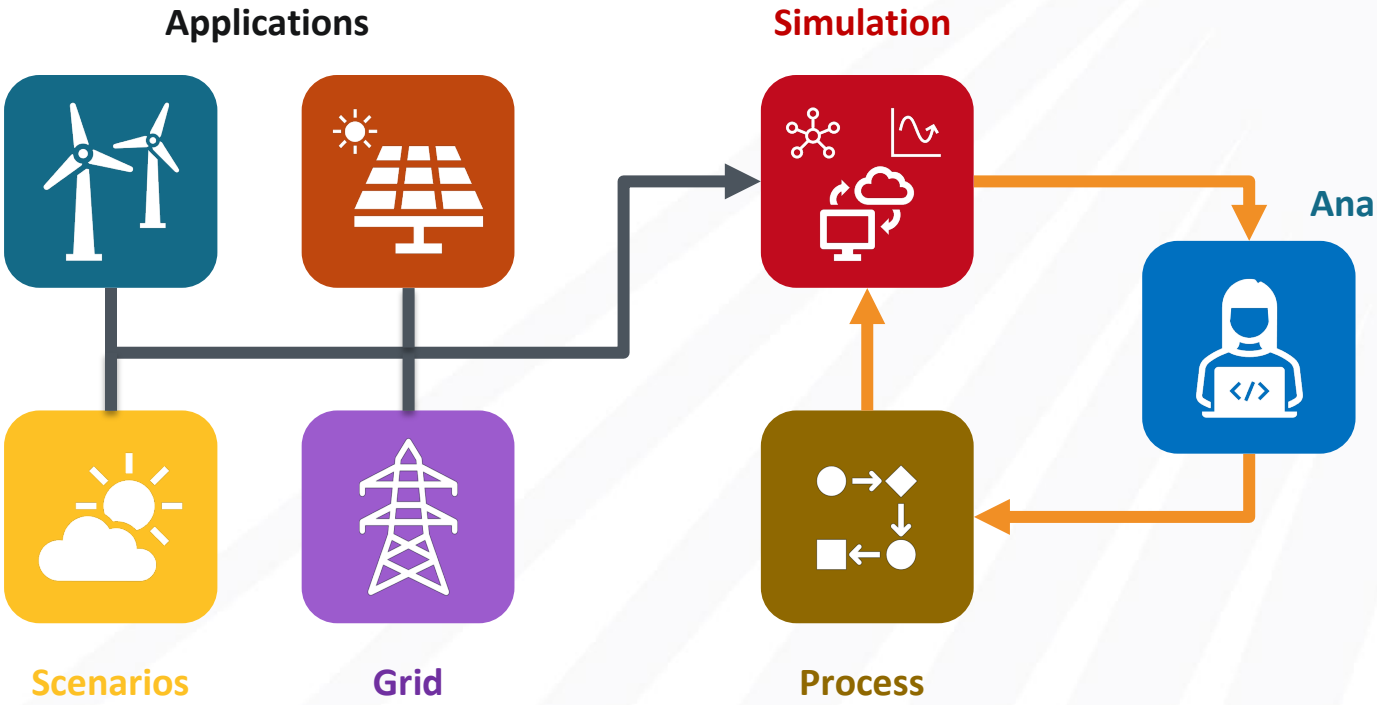
Sprint Studies with Public Data and Tools



Known Gaps

- 50kW - 5MW
- Environment
- Equity
- Custom Data

Technical Guide to Interconnection Studies



NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

IEC

IEEE SA
STANDARDS ASSOCIATION

5-Year Strategic Interconnection Roadmap

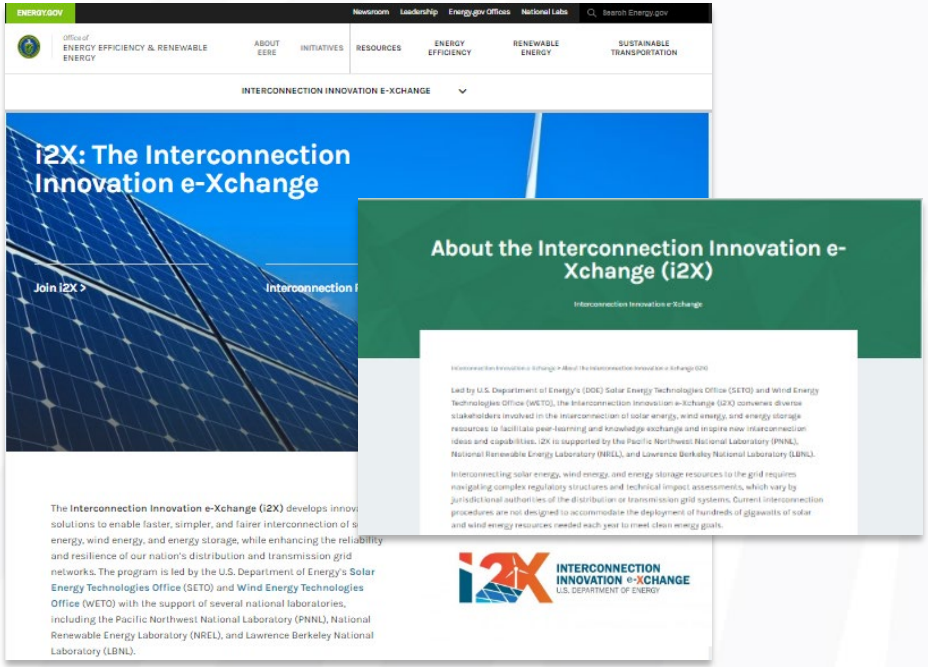
- Expert-Informed Goal Setting
- Success Milestones & Research Gaps
- Transparent Key Performance Indicators

- Customizations for Size and Region
- Transition Planning for New Processes
- Buy-in, Adoption, and Updates

i2X “Information Clearinghouse”

BOOKMARK THE WEBSITE

Be sure to visit the i2X website for any and all information regarding the program: energy.gov/i2x



Engagement Mechanisms

Working Groups

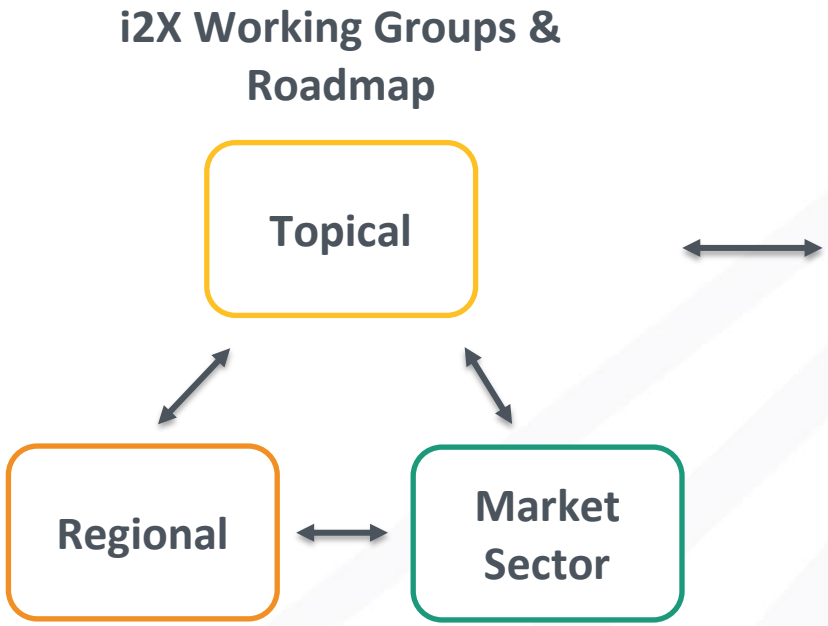
Regional
- Northeast
- Mid-Atlantic
- + more

Sector
- Utilities
- Developers
- + more

Topic
- Energy Justice
- Standards Adoption
- + more

Engagement Platform

Planned Cross-Coordination



Other DOE/Lab Assistance Work Efforts

- Market Information/Reports
- GMLC State Technical Assistance
- Office of Clean Energy Demonstrations (OCED) Efforts, e.g., Rural-Remote TA
- Labs Support for Technical Standards Development, Leadership & SME Engagement

Potential Workgroups to Date – Distribution Standards Focus

Topical Workgroup

- Technical Standards Implementation – **Distribution** (IEEE Std 1547)

Market Sector Subgroups

- Regulators
- Developers
- Utilities
- Govt. (e.g., FEMP)

Regional Subgroups

- Geographical?
- Utility territory?
- By deployment maturity?

"Urgent Need" or Targeted Focus Areas (potential application of i2X Rapid Technical Assistance and Sprint Studies)

- Safety/anti-islanding/alternatives to direct transfer trip
- Data access & privacy
- Energy Equity/Justice Focus
  - Remote-Rural?
  - Tribal?

i2X Technical Assistance

Goal: To provide access to various interconnection technical assistance opportunities to support our partners in their implementation of developed reforms

- **Interconnection Office Hours**
  - Direct Access to i2X Leadership
- **Preliminary i2X Working Groups**
  - Energy Justice Working Group
  - IEEE 1547-2018 Adoption Support Working Group
  - Experienced Peer Learning Webinar Series
- **Additional Topics For Consideration**
  - Implementing Queue Management Methods
  - Accelerated Tool Development and Deployment
  - Best Practices and Training
- **Others? - Suggest a topic!**

Workshop Team Activity
Prioritization & Discussion

What worries are still going to keep you up tonight?

1. Jointly develop list of current interconnection challenges for PUCs
2. Prioritize
3. Discuss what types of assistance would be most helpful

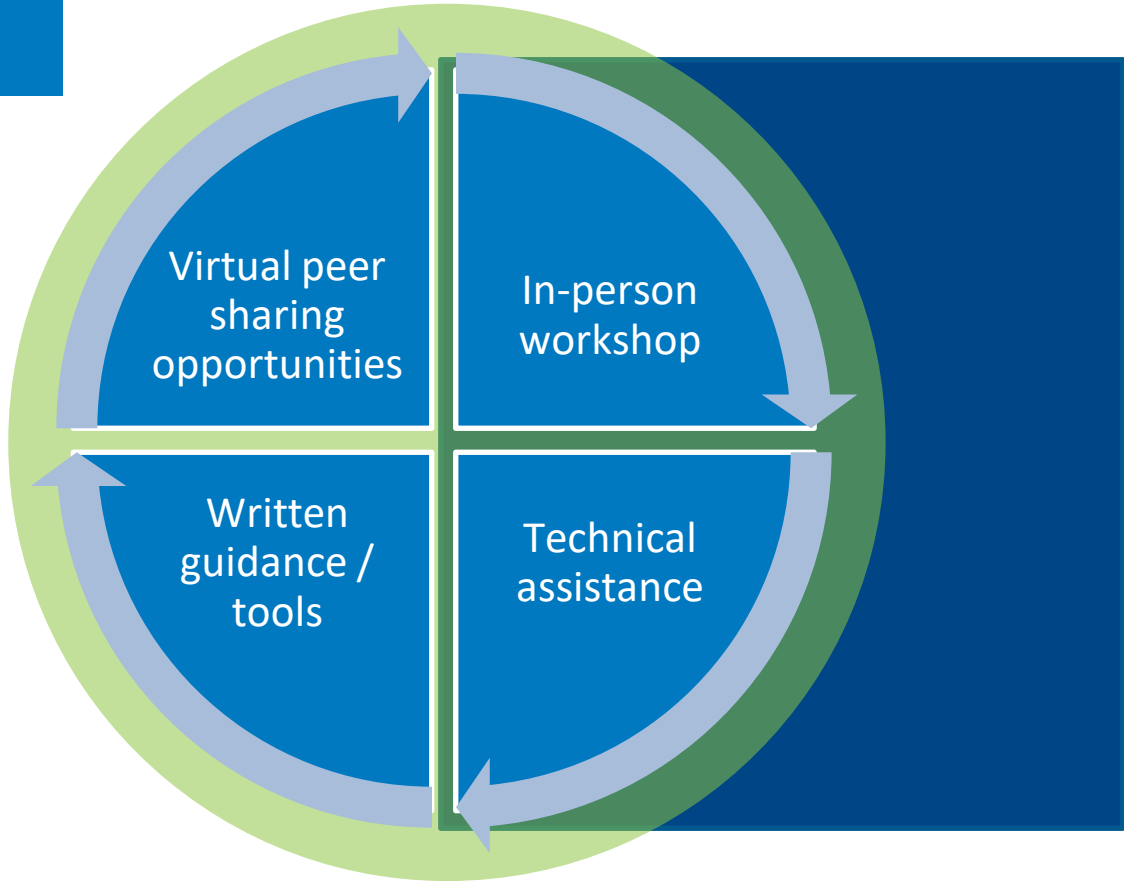
Agenda for Today's Interconnection Workshop

Time	Topic	Activity
8:30am	Welcome & Level-Setting ● Introductions ● Objectives & agenda review	Journaling & Sharing ● What are you worried about re: DER interconnection?
9:10am	Existing Resources & Support ● When & how to approach updating stds ● Hands-on with NREL-developed guides ● IEEE resources	Walk-Through with Participant Questions · Myth busting
10:25am	Break	
10:45am	Interconnection Challenges & Needs ● DOE's new I2X initiative ● Identify needs for technical assistance	Brainstorm & Prioritize ● Topics requiring assistance ● Activities that can be helpful
11:45am	**Resources & Next Steps** ● Available & forthcoming support	**Update Your Calendars**
12:00pm	Adjourn	

Resources & Next Steps

RELATED NARUC EVENTS & OPPORTUNITIES

- NARUC members-only Regulators' Roundtables on DER Interconnection Processes *virtual, October 24, 2022*
- NIST Smart Grid interoperability technical assistance
  ongoing; see Jeff Loiter for FY23 opportunities
- NARUC Grid Data Sharing Collaborative *framework for demo in Spring 2023*



NARUC Center for Partnerships & Innovation

Contact us for existing and future resources on DER and BPS interconnection

Danielle Sass Byrnett Senior Director dbyrnett@naruc.org 202-898-2217	Jeffrey Loiter Technical Director jloiter@naruc.org 202-656-2128
Tanya Paslawski Partnerships & Policy Director tpaslawski@naruc.org 517-819-9683	Kiera Zitelman Technical Manager kzitelman@naruc.org 202-898-2212

www.naruc.org/cpi

What's Next?

BOOKMARK THE WEBSITE

Be sure to visit the i2X website for any and all information regarding the program: energy.gov/eere/i2x

JOIN THE PARTNERSHIP

Join the growing list of i2X partners to benefit from all that the i2X program has to offer

Partner Benefits

- Access to the Online Stakeholder Platform
- Participate in Working Groups
- Direct Access to Interconnection Experts
- Workshops and Informational Resources
- Feedback on Deliverables
- Technical Assistance Opportunities

PARTICIPATE IN UPCOMING EVENTS

Join any one of the amazing opportunities to connect with i2X leadership such as our **Interconnection Office Hours**

INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

Upcoming: Rural & Remote TA

Program Design In Progress

Michael Ingram | Michael.Ingram@NREL.gov
David Narang | David.Narang@NREL.gov

INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

Thank You!

Website: energy.gov/i2X