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

Queue Management & Cost Allocation
DER Readiness | 4/27/23

An initiative spearheaded by the Solar Energy Technologies Office and the Wind Energy Technologies Office

Meeting Notes

Notes synthesizing keys points, insights and questions from the meeting can be found here:https://app.box.com/s/ujyut6jpc8t9ce6bigbjrjv3uu8jcxaq

Interconnection Innovation e-Xchange (i2X)

Mission: To enable a **simpler**, **faster**, and **fairer** interconnection of clean energy resources while enhancing the **reliability**, **resiliency**, and **security** of our **distribution and bulk-power electric grids**

Stakeholder Engagement

Nation-wide engagement platform and collaborative working groups

Data & Analytics

Collect and analyze interconnection data to inform solutions development

Strategic Roadmap

Create roadmap to inform interconnection process improvements

Technical Assistance

Leverage DOE laboratory expertise to support stakeholder roadmap implementation

The first half of this Teams call is being recorded and may be posted on DOE's website or used internally. If you do not wish to have your voice recorded, please do not speak during the call. If you do not wish to have your image recorded, please turn off your camera or participate by phone. If you speak during the call or use a video connection, you are presumed consent to recording and use of your voice or image.

Virtual Meetings Code of Conduct

1. *Assume good faith and respect differences*
2. *Listen actively and respectfully*
3. *Use "Yes and" to build on others' ideas*
4. *Please self-edit and encourage others to speak up*
5. *Seek to learn from others*

Mutual Respect . Collaboration . Openness

Key Outcomes from i2X e-Xchange Meetings

- Inform and formulate a ***publicly available***, strategic roadmap for interconnection
  - Topical challenges and issues
  - Practical solutions to implement and scale
  - Knowledge and data gaps and new solutions to pilot
  - Success goals and measures of success
- Summary documentation for each meeting regarding ideas discussed and opportunities for targeted stakeholder action
- Provide platform for ongoing engagement before and after meetings
- **Longer term vision** → Solution e-Xchanges to continue building a national forum for all stakeholders as a community of practice, excellence, and innovation

i2X Solution e-Xchange Topic Areas

- **Queue Management and Cost Allocation**
  - Technology, regulation, administration, and organizational change focus
  - *What* innovative interconnection solutions exist?
- **Grid Engineering Practices and Standards**
  - Engineering and technology focus
  - *How* can proposed solutions be executed?
- **Equity and Energy Justice**
  - Multidisciplinary
  - *Who* is impacted by and benefits from proposed solutions?
- **Data Transparency**
  - Multidisciplinary
  - *What* transparency concerns must be addressed?
- **Interconnection Workforce and Training**
  - Multidisciplinary

Additional subjects, like capacity maps, cross these topics and will be addressed from these different perspectives. Follow the schedule of events on the i2X website.

Agenda

- **Distribution Research and Gaps**
  - Jeff Cook, NREL
  - Todd Wall, PNNL
- **Innovation Panel**
  - Radina Valova, Interstate Renewable Energy Council
  - David Gahl, Solar and Storage Industries Institute
  - Tamer Rousan, Electric Power Engineers
- **Interactive Discussion**

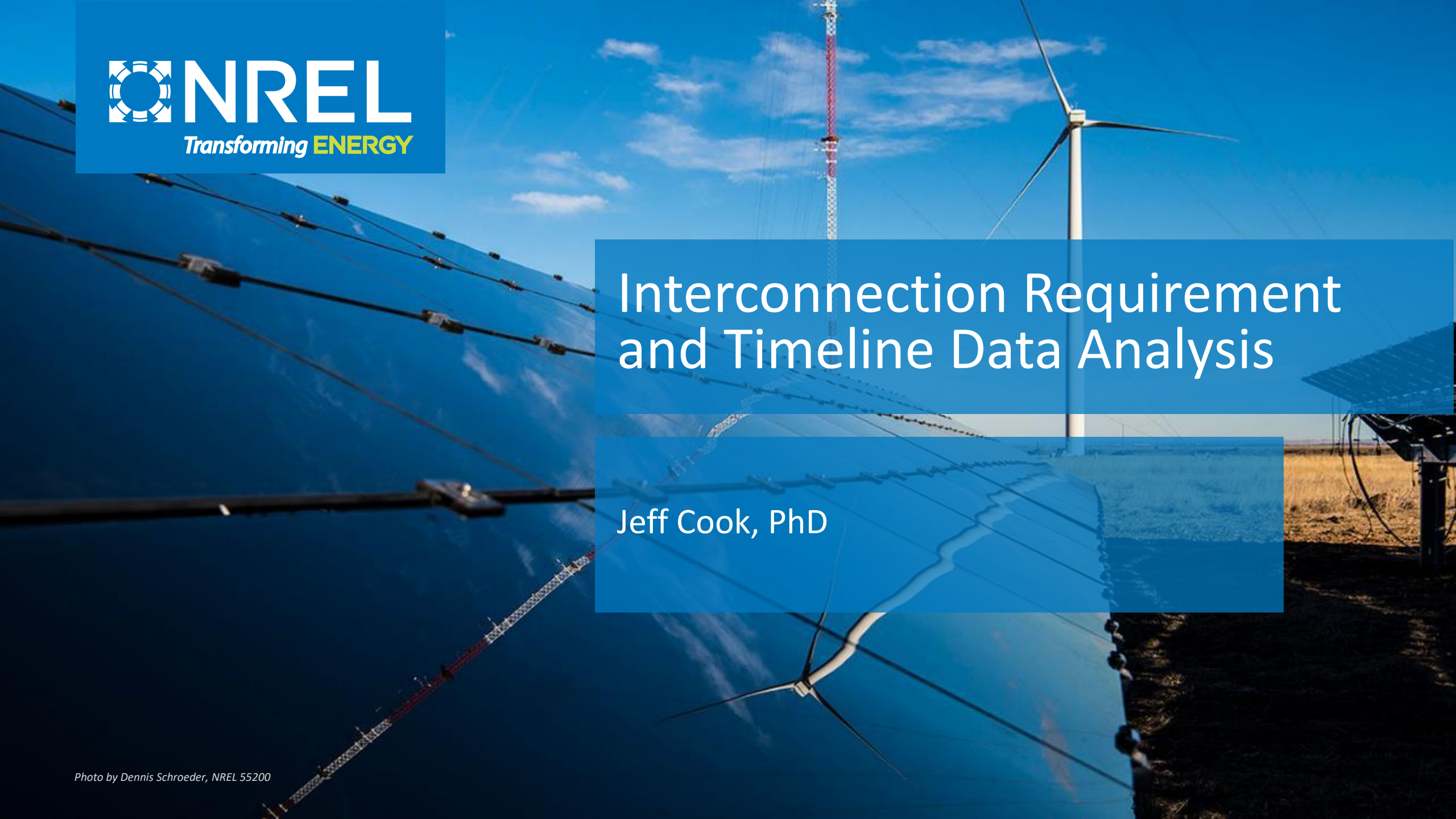
Upcoming Solution e-Xchanges

1. May 3rd (Wed) 2-4PM ET: Distribution System Protection with High DER Adoption Levels
2. May 11th (Thurs) 2-4PM ET: Managing the Bulk Power System Interconnection Study Process
3. May 17th (Wed) 2-4pm ET: EEJ Interconnection Considerations and Approaches
4. May 24, (Wed) 2-4 p.m. ET: DER Interconnection Approaches & Flexible Interconnection

Follow the schedule of events on the i2X website.

Distribution Level Research and Gaps

NREL Activities



Interconnection Requirement and Timeline Data Analysis

Jeff Cook, PhD

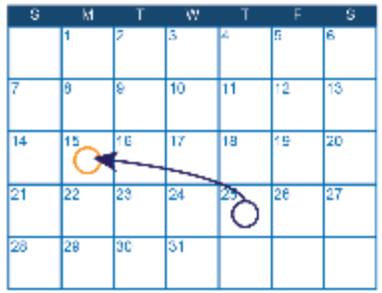
Photo by Dennis Schroeder, NREL 55200

NREL Permitting, Inspection, and Interconnection Research Agenda

- **Analysis**
  - Identify PII-related process requirements, cycle times, and cancellations across all municipalities.
  - Provide technical assistance to support decision makers
  - Resource development to improve IX processes nationwide

SolarAPP+

Shorter project timelines



A typical SolarAPP+ project is permitted, installed, and inspected around 13 business days sooner than traditional projects

Based on differences in median durations

Staff time savings

NREL estimates SolarAPP+ saved around 9,900 hours of jurisdiction staff time through automated permit reviews in 2022

Potential inspection benefits

(further research required)

SolarAPP+ projects have been about 29% less likely to fail inspections than traditional projects

Based on data from 12 jurisdictions

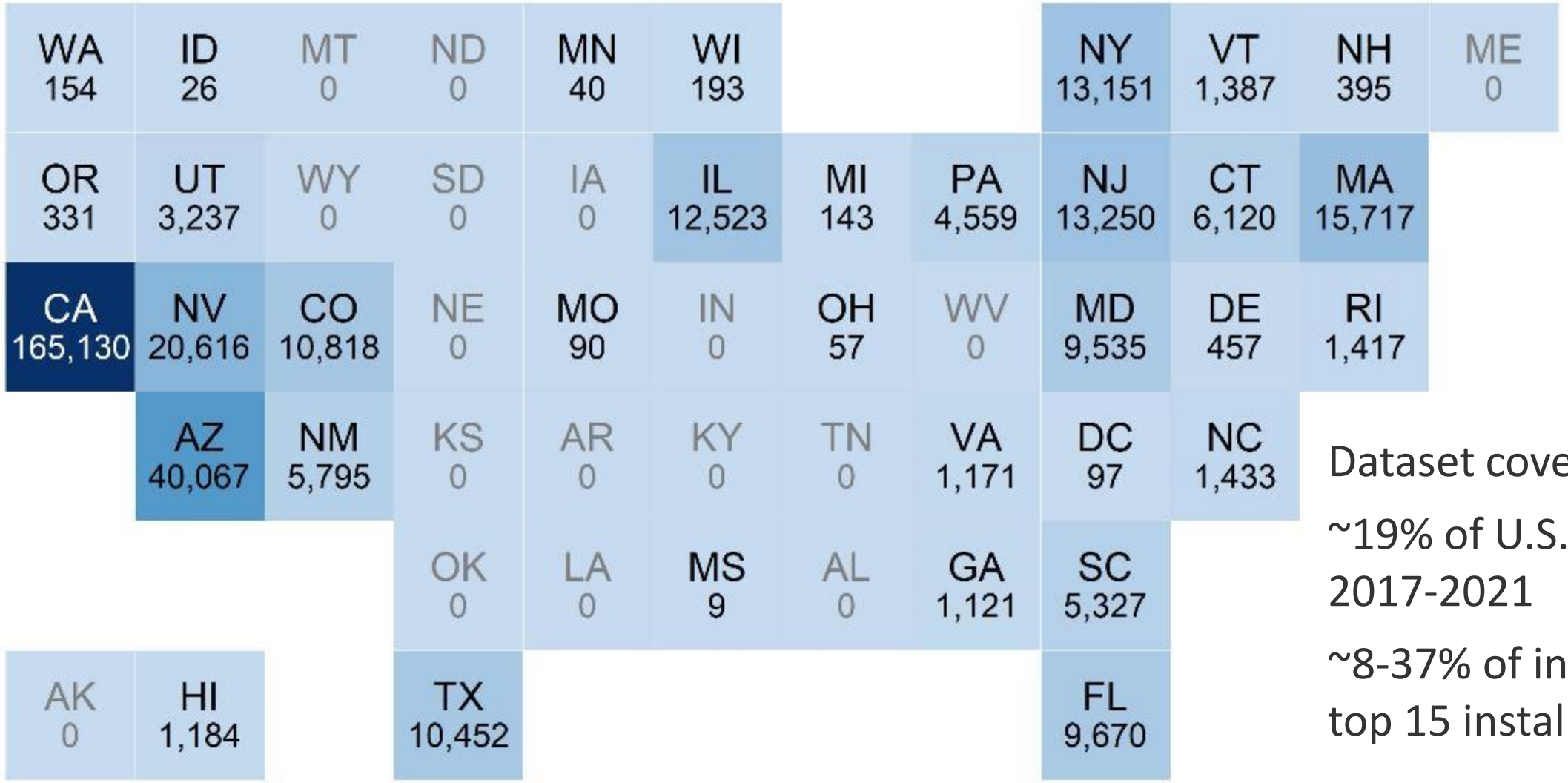
NREL's Timeline Analysis

https://solarapp.nrel.gov/solarTRACE

https://www.nrel.gov/solar/market-research-analysis/permitting-inspection-interconnection-timelines.html

SolarTRACE Project-Level Dataset

Res. PV-only projects
from 13 installers
Installed 2017-2021

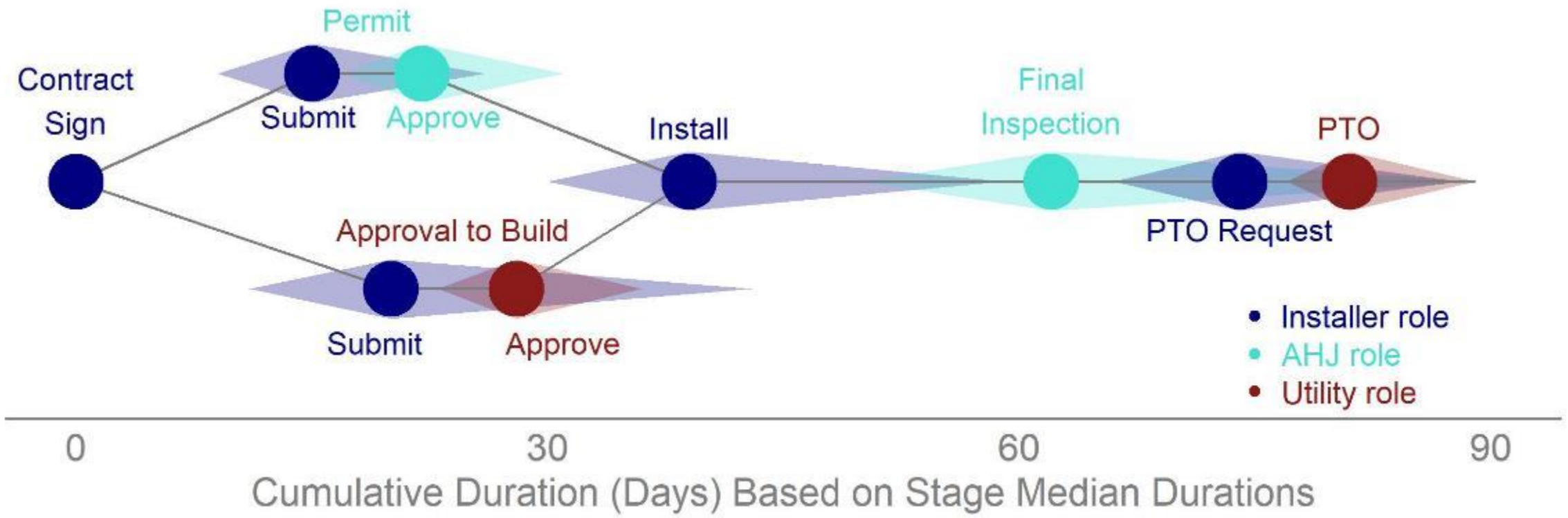


Dataset covers:

~19% of U.S. installs 2017-2021

~8-37% of installs for top 15 install states

Residential PV Adoption Process

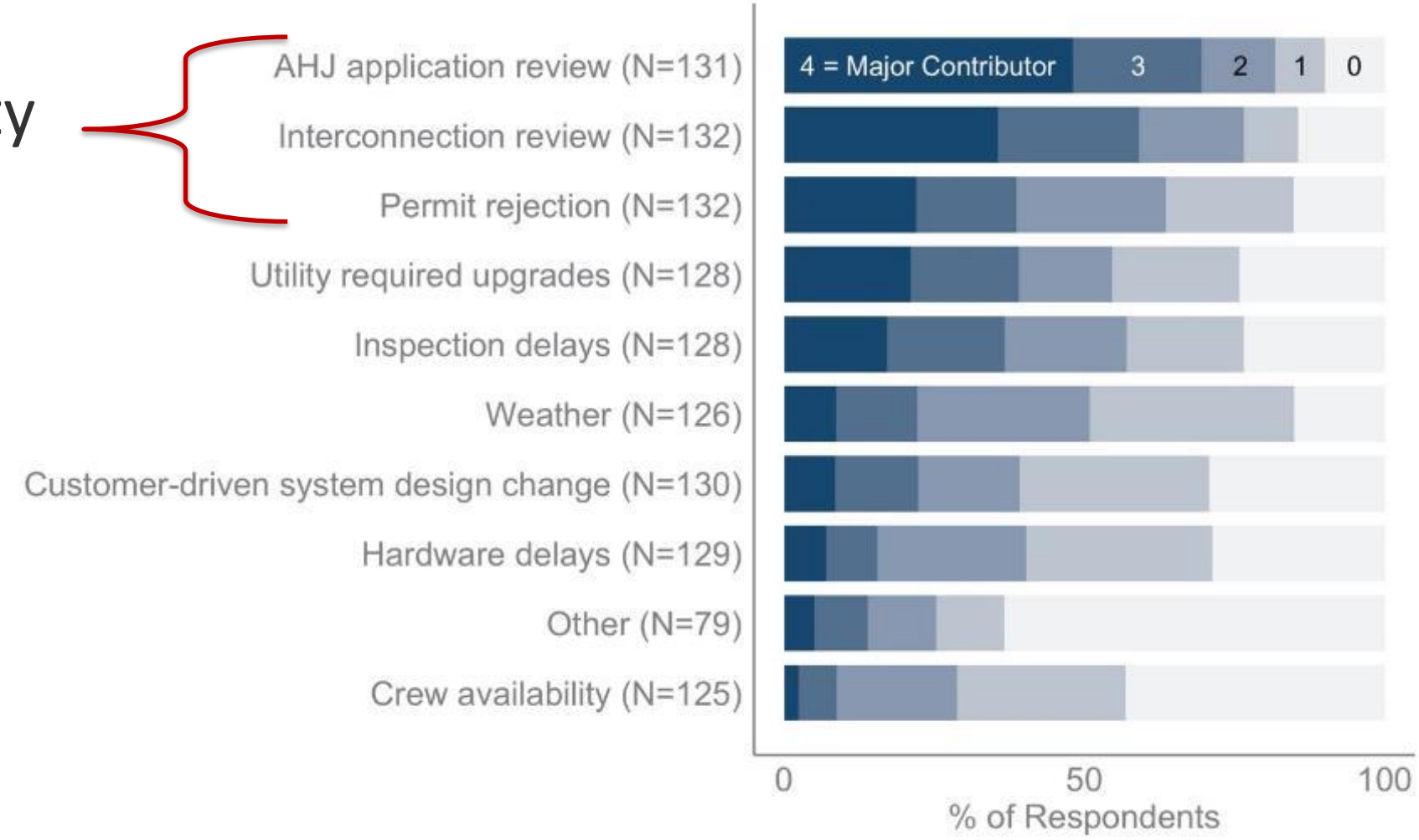


Since 2019, a typical residential PV project took **10-22 weeks** between contract and operation

- A typical permit took **1-2 weeks**
- Inspections took **2-3 weeks or more**

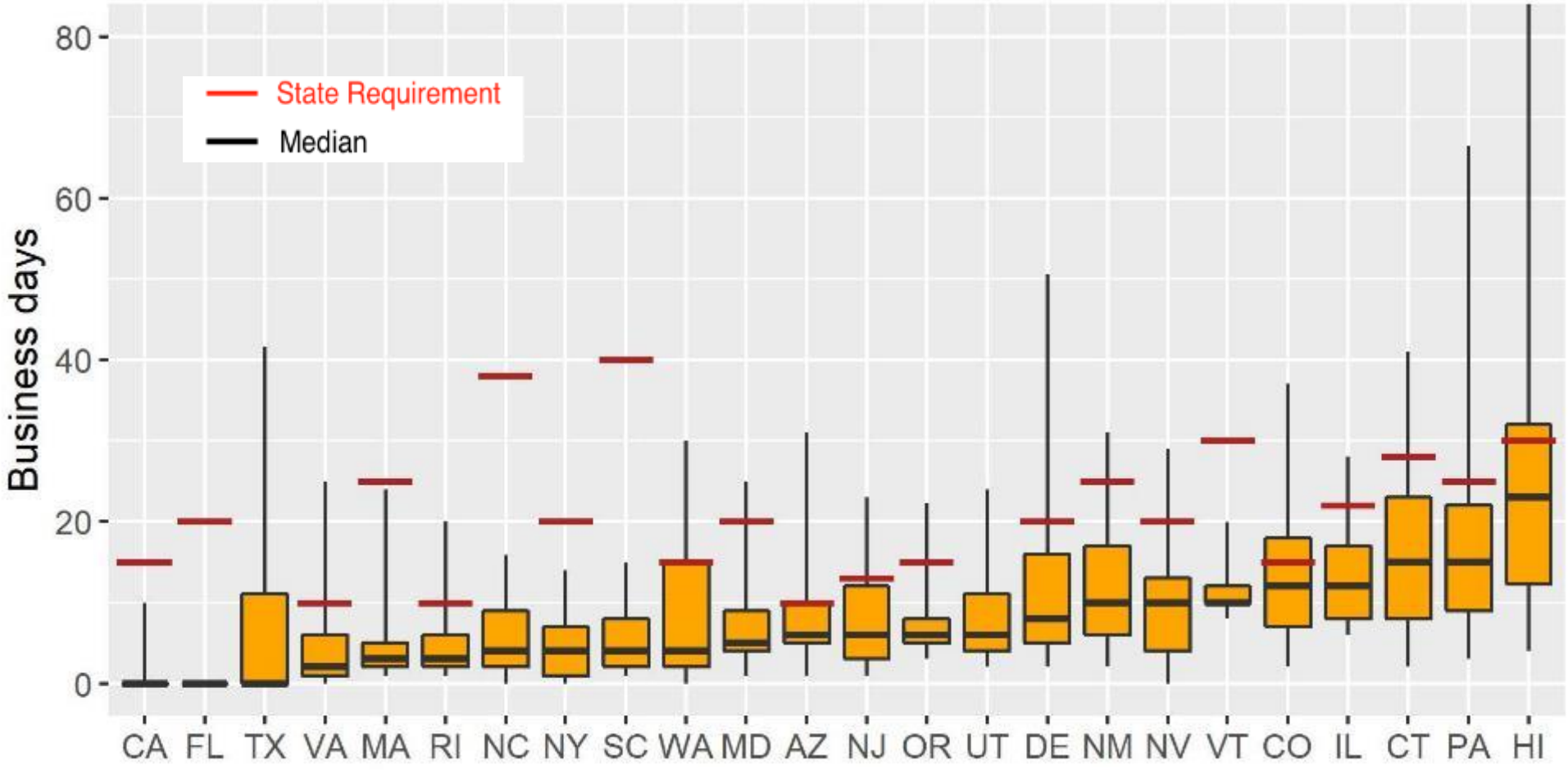
Major Project Delay Contributors (Installer Survey)

AHJ permit and utility interconnection application reviews were the most-cited reasons for major project delays



Utility Pre-Install Review Timelines

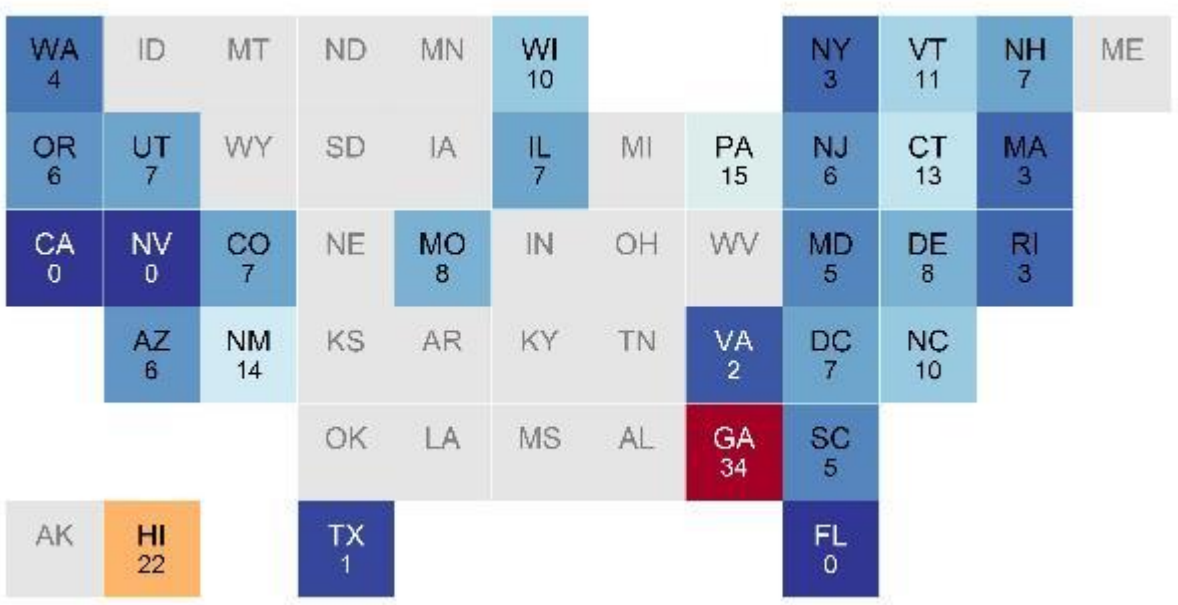
PV-Only | 1-10kW
Installed 2017-2019



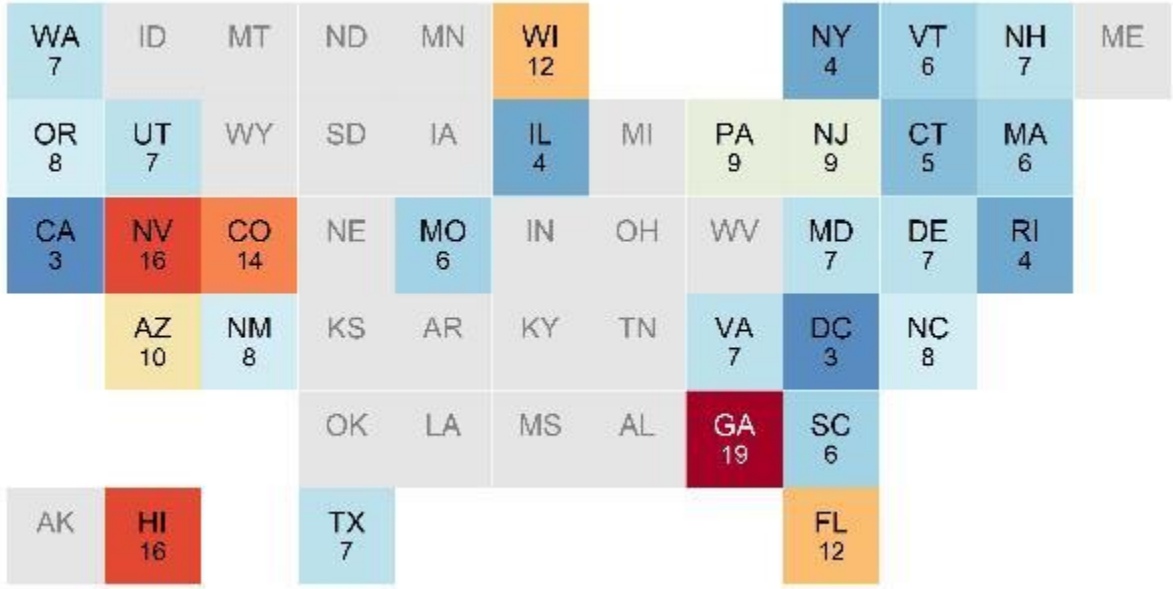
- Most projects at most utilities meet state-mandated maximum review times for pre-install IX applications
- More stringent state-level requirements not strongly associated with faster review times

ATB Review and Post Install Review

- Utilities in some states have streamlined approval to build (ATB) processes and post-install review.
- Others have longer ATB and post-install reviews.



ATB median review time



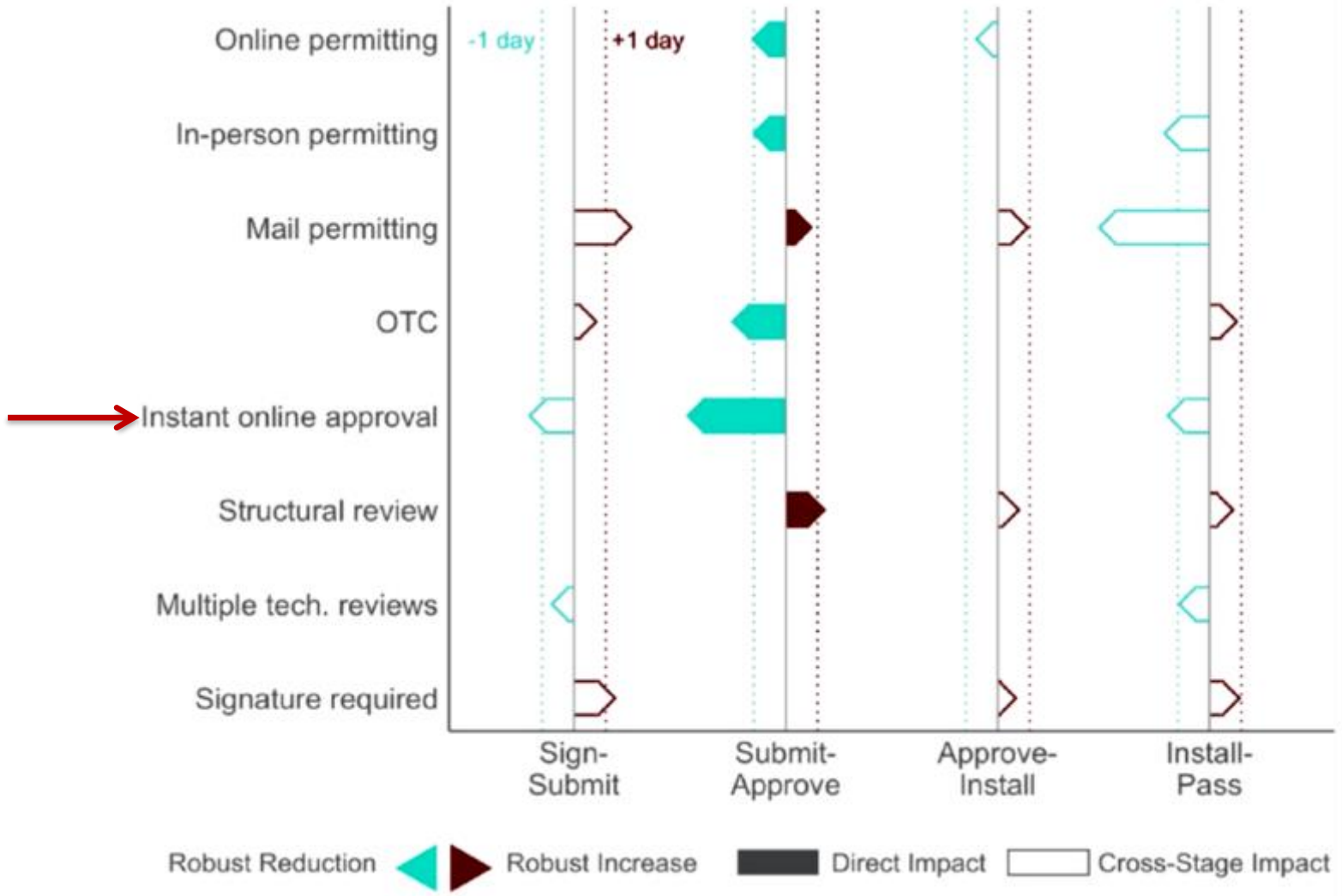
Post-install, PTO median review

Permitting Factors Affecting Timelines

Online-instant permitting (like SolarAPP+) shows the most robust timeline decreases

→ No negative impact on post-install timelines

It is unclear how IX requirements influence timelines and costs.



Call to Action

- NREL is actively looking for partners to:
  - Review SolarTRACE and provide feedback/suggestions for functionality and visualization improvements
  - Provide project-level data, with an emphasis on:
    - 2022 data to update SolarTRACE
      - **PV+Storage projects**
      - **PV projects installed on new homes**
      - **PV projects at time of re-roof**
      - **AHJ permitting data (i.e. code years and online permitting processes)**

NREL's Technical Assistance relative to Interconnection

Interconnection Cohort States: AR, KY, MA, NJ, UT

Project Overview

In collaboration with Cohort states (AR, KY, MA, NJ, UT) develop interconnection priority topics, agendas and present virtual public workshops.

Accomplishments

- Workshop #1 (12/12/2022): "Bulk Power System Considerations and Coordination: Aggregation and FERC Order 2222"
- Workshop #2 (03/08/2023): "Modern DER Capabilities and Deployment Considerations"
- Workshop #3 (mid/late May): "Improving the Interconnection Process"
- All materials are posted @ https://www.nrel.gov/grid/ieee-standard-1547/workshops.html

Workshop Goals

- Increase awareness of existing materials & available support to help state PUCs move forward on DER interconnection activities
- Help participants make connections to colleagues with similar challenges (and solutions!)
- Help project team understand context and implementation challenges

Lab Lead: Michael Ingram (NREL)

NREL's IEEE 1547-2018 Resources Website

nrel.gov/grid/ieee-standard-1547

An online platform with educational resources to aid stakeholders in the successful adoption and implementation of IEEE 1547-2018.

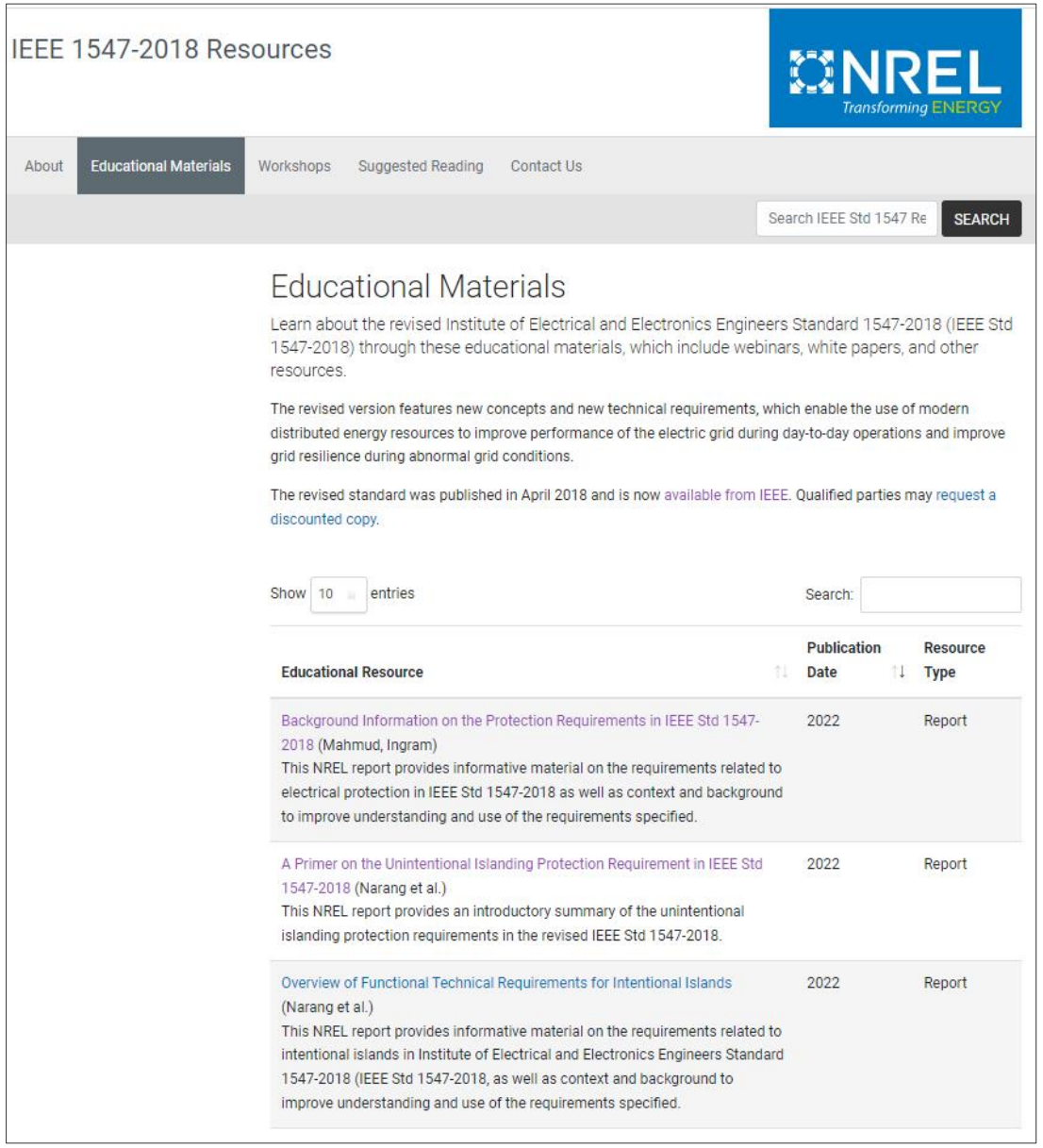
Sponsored by:
Solar Energy Technologies Office

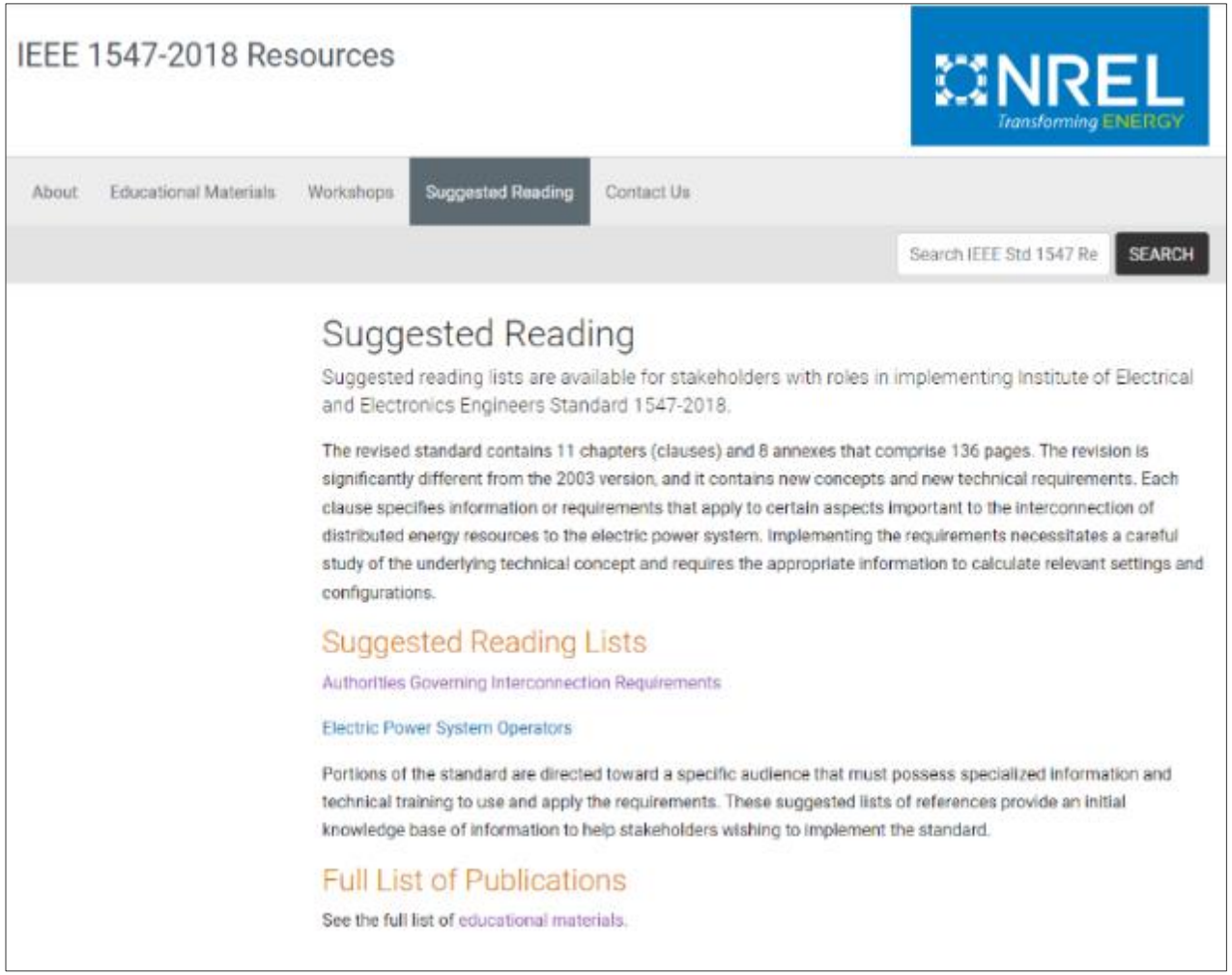
Partners and Advisors:
- Sandia National Laboratories
- Institute of Electrical and Electronics Engineers
- Electric Power Research Institute
- National Association of Regulatory Utility Commissioners
- National Rural Electric Cooperative Association
- Interstate Renewable Energy Council
- Regulatory Assistance Project
- Western Interstate Energy Board


Illustration by Fred Zietz, NREL

NREL's well-catalogued and publicly accessible online platform includes **presentations, industry white papers, and topic-specific NREL technical reports for utilities, states, solar developers, transmission operators, and other stakeholders.**

Resources on the Site





nrel.gov/grid/ieee-standard-1547

An NREL Guide for Authorities Governing Interconnection Requirements

A Guide to Updating Interconnection Rules and Incorporating IEEE Standard 1547-2018 presents a structured, step-by-step approach to help governmental authorities that oversee interconnection requirements and other stakeholders develop and update interconnection rules. The NREL-published report considers the incorporation of the new standard from both process and technical standpoints.

- Three main sections to report:

- Key considerations include:
  - Has the governing authority sufficiently identified motivations for updating the interconnection rule? How do the identified technical requirements relate to the desired outcome?
  - Has the governing authority allowed for the use of DER capabilities (even if they are to be used in the future)?

Any state or local jurisdictions that are interested in adopting IEEE Standard 1547-2018 should consult this resource!

Find the full report on NREL's IEEE Resource Website or at nrel.gov/docs/fy22osti/75290.pdf.

https://www.nrel.gov/solar/market-research-analysis/permitting-inspection-interconnection-timelines.html

Questions and Thank You!

For more information contact:
jesse.cruce@nrel.gov and
jeff.cook@nrel.gov

www.nrel.gov

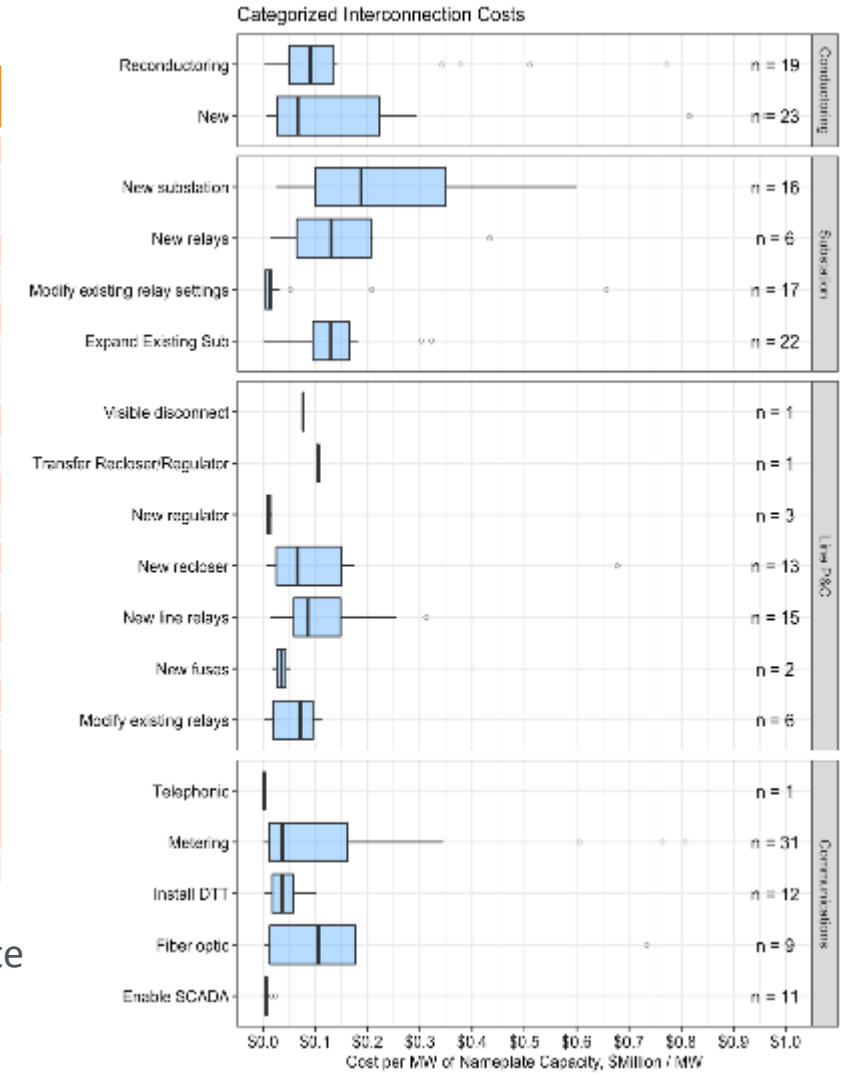
This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

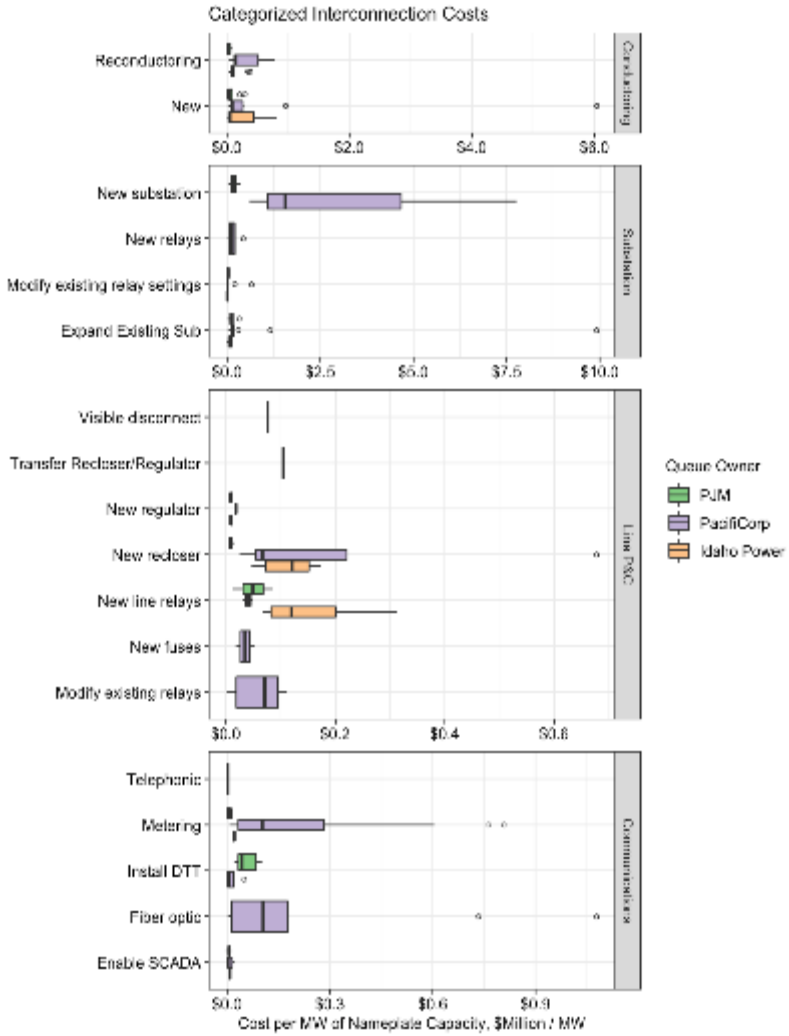
PNNL Hydro Research

Network Upgrade Cost Benchmarking

System Category	Subdivided System Upgrade Classes	Samples
Conductoring*	New Conductors	23
	Upgrade Existing Conductors	19
Substation*	Expand Existing Substation	17
	New Substation	6
	New Relays	22
	Modify Existing Relay Settings	16
Line Protection and Control*	New Regulator	3
	New Recloser	13
	New Line Relays	15
	Modify Existing Relays	6
	New Fuses	2
	Visible disconnect	1
	Transfer Recloser/Regulator	1
Comm*	Fiber Optic Cable	9
	Telephonic Connection	1
	Enable SCADA	11
	Install DTT Capability at Neighboring Subs/Control Centers	12
Metering*		31

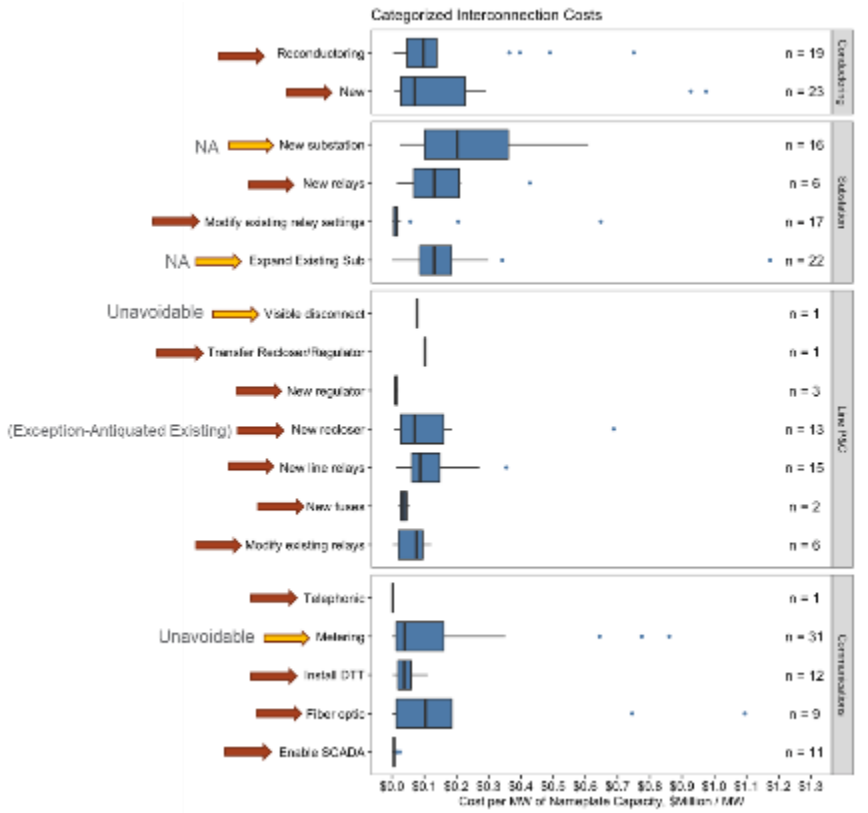
*Various technology options may mitigate (some of) these upgrade costs





IEEE 1547.7 - IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Interconnection

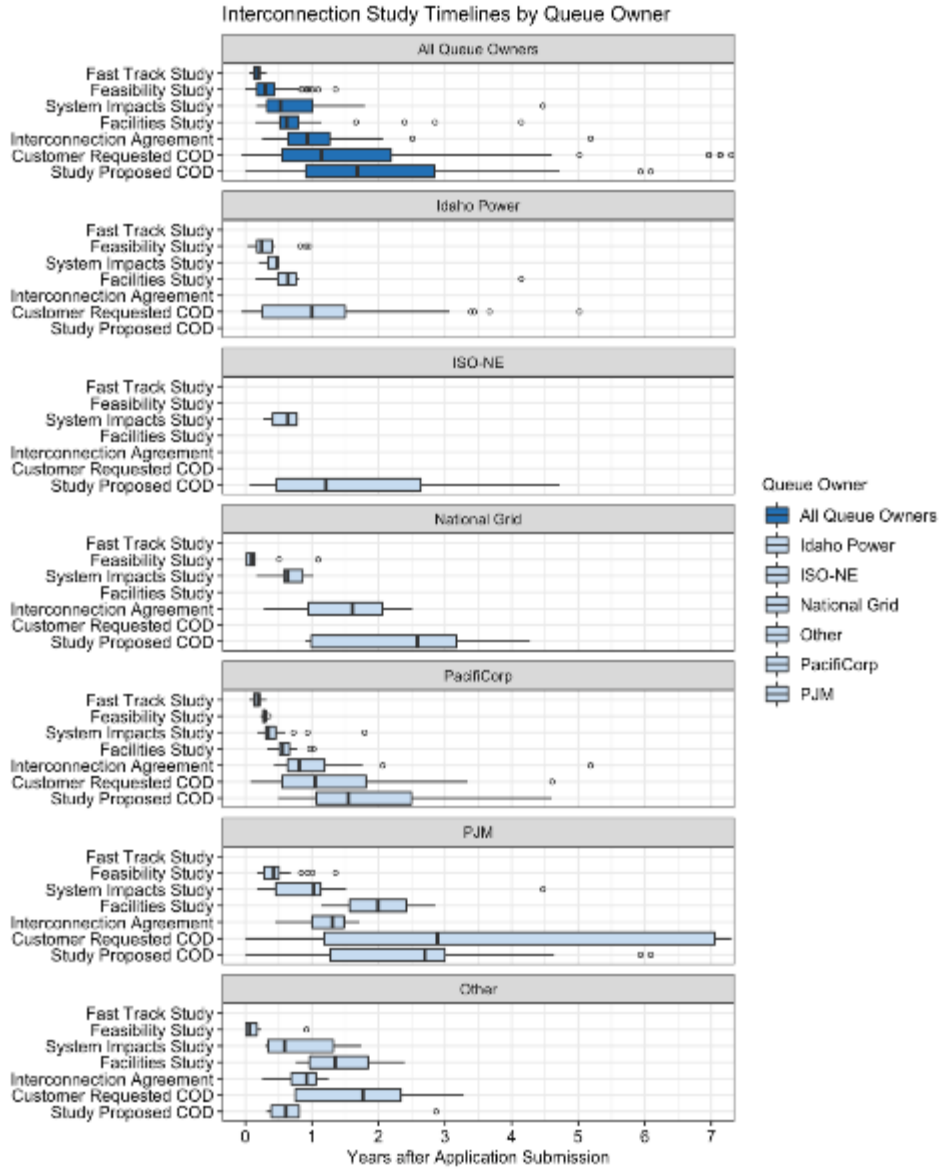
Criteria ID	Preliminary Review Criteria and Sub-Criteria	Conventional Upgrades	Proposed
P1	**Use of certified DR equipment**	NA	No Upgrade
P2	**Potential for Unintentional Island**		
P2.1	DR does not export power to area EPS at the PCC	No update required	No Upgrade
P2.2	DR production relative to served load (penetration) is small	Conductor upgrades, Voltage Regulators, Capacitor Banks, Protection & Control (Recloser)	Flexible PCC Closer to Concentrated Loads
P2.3	DR interconnection incorporates acceptable anti-islanding protective features	Enable SCADA (Remote Terminal Unit, Comm Upgrades, Direct Transfer Trip (DTT, fiber-optic lines)	PE advanced island detection, proximity to existing grid reclosing device, SCADA available
P3	**Impact on EPS equipment loading under all steady state conditions**		
P3.1	Gross kVA rating of aggregate DR is no greater than the kVA rating of the EPS transformer serving the facility on a per phase basis.	NA	NA
P3.2	Gross kVA rating of aggregate DR on a particular feeder or substation is no greater than the feeder or substation rating.	New substation, substation expansion , conductor upgrades, protection & control ($$$)	DER Sized for PCC Location
P4	**Impacts on system protection, fault conditions, and arc flash rating**		
P4.1	DR cannot cause any protective device or circuit component to exceed 85% to 90% of the short circuit interrupting capability	New Relays, Relay Mods, DTT, SCADA/Comms, Conductor Upgrades, Reclosing Device Modification or Repositioning	DER Operating Under Same Config as existing recloser, Accept Control Signals from Recloser, PE not able to provide short circuit current
P4.2	Aggregate DR on circuit does not contribute more than 10% of the circuit's maximum fault current at the primary voltage point nearest the PCC.	New Relays, Relay Mods, DTT, SCADA/Comms, Conductor Upgrades, Reclosing Device Modification or Repositioning	DER Operating Under Same Config as existing recloser, Accept Control Signals from Recloser, PE not able to provide short circuit current
P4.3	DR will interconnect with an Area EPS having radial topology	Assumed	Assumed
P4.4	DR will not cause temporary over-voltages during a phase to ground fault	New Relays, Relay Mods, DTT, SCADA/Comms, Conductor Upgrades, New reclosing device modification or repositioning	PE able to provide fast response, PE not able to supply short circuit current
P4.5	Existing protection schemes are configured to allow for DR connected to the Area EPS	New Relays, Relay Mods, DTT, SCADA/Comms, New Recloser, Recloser Modification/Repositioning	DER operating under same protection settings as existing recloser, accepts control signals from existing Recloser/SCADA
P5	**Impacts on voltage regulation within the EPS under steady state conditions**		
P5.1	DR PCC is relatively strong or stiff location within the Area EPS	New Relays, Relay Mods, DTT, SCADA/Comms, Conductor Upgrades, New reclosing device, Recloser modification or repositioning	Flexible PCC physically closer to concentrated loads and more stiff distribution facilities
P5.2	DR would not be anticipated to result in voltage rising above specified limits in the Area EPS	New Relays, Relay Mods, DTT, SCADA/Comms, New/Reposition Voltage Regulators, New/Reposition Capacitor Banks	PE Enabled Fast Response and Voltage Support, Absorb Reactive Power, More Stiff PCC
P5.3	Loss of DR or variation in output of DR would not be anticipated to result in voltage in the Area EPS falling below specified limits	New Relays, Relay Mods, DTT, SCADA/Comms, New/Reposition Voltage Regulators, New/Reposition Capacitor Banks	PE Enabled Fast Response and Voltage Support, Possible voltage affect in case of unanticipated trip
P5.4	Variation in output of DR would not be anticipated to necessitate changes of settings of Area EPS voltage regulating devices.	New/Reposition Voltage Regulators, New/Reposition Capacitor Banks, New/Modify Relays	PE Enabled Fast Response and Voltage Support, DR located in more stiff location,
P5.5	DR is not expected to result in high voltage on shared secondary.	NA, primary interconnection assumed	NA, Primary interconnection assumed
P6	**Impacts on EPS power quality**		
P6.1	DR operation will not cause flicker exceeding limits at the PCC.	New/Reposition Voltage Regulators, New/Reposition Capacitor Banks, New/Modify Relays	PE Enabled Fast Response and Voltage Support
P6.2	Real and reactive power flow from DR will not cause Area EPS voltage sags and swells	New Regulators, New Capacitor Banks	PE Enabled Fast Response and Voltage Support
P6.3	DR operation will not cause harmonics at the PCC to exceed allowed limits	UL Certification, Further Testing	To be determined

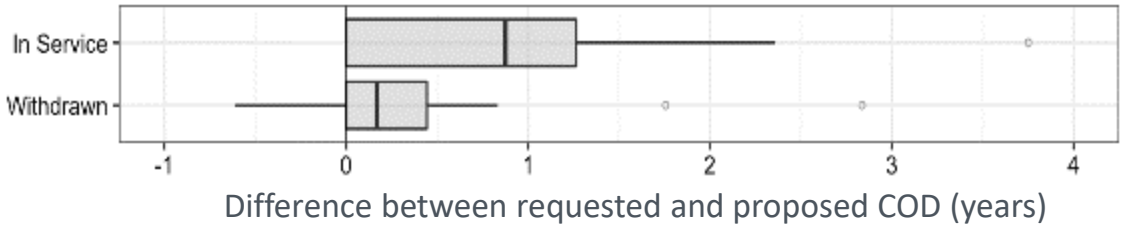


Mitigated

Unavoidable

Network Upgrade Timeline Benchmarking





Of note:

- System Impact Study and securing an IA are long lead-time items
- Majority of reviews target Commercial Operation Dates (CODs) within 3 years
- Delays between customer requested and study proposed CODs are common
- Less delays between requested and proposed CODs for withdrawn projects than in-service projects suggest that timeline delays are not influencing the decision to pursue a project

Innovation Panel

Panel Questions

- Who is testing and implementing the most innovative approaches to DER QMCA today?
- What are the common IX innovation objectives for developers and utilities?
- What is needed generally to successfully implement innovative queue management and cost allocation approaches for the majority of future DERs?
- What do IX stakeholders want from DOE and i2X regarding queue management and cost allocation?

Interactive Discussion

Interactive Questions

- If you could magically change one thing about IX, what would it be?
- One word answers:
  - What are the most EXPENSIVE IX-related costs?
  - What is most UNCERTAIN about IX?
- Rank cost and occurrence of common upgrades
- What innovative and emerging approaches to queue management and cost allocation are the most PROMISING? What are the most CONCERNING?
- What do IX stakeholders want from DOE and i2X regarding queue management and cost allocation?