



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

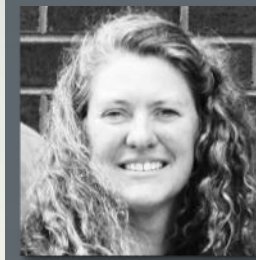
an EERE collaboration between SETO & WETO

ESIG Workshop

August 11th, 2022

- Program Overview
- 5-year Roadmap

energy.gov/i2x



Presenter

Dr. Cindy Bothwell

Grid Integration Engineer
Wind Energy Technologies Office

AGENDA

1

Interconnection
Background

2

i2X Program

3

Roadmap
Development

4

Audience
Input

What is Interconnection?

The complex network of regulatory electricity market laws, administrative processes, and integration technologies that together define the processes for connecting new generation to grid networks

Background of the Interconnection Challenge

Interconnection is Changing as the Grid Transforms

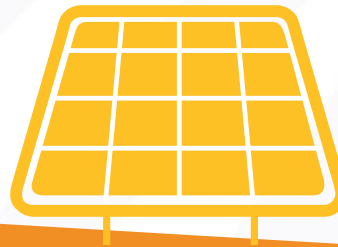
Zero-Carbon Future

Need for paradigm-shifts to
deploy clean energy technologies
at exponential scales



Complexity

Rapid grid transformation
Complex and varying processes
High penetration weather based
Technology advancement



Equity

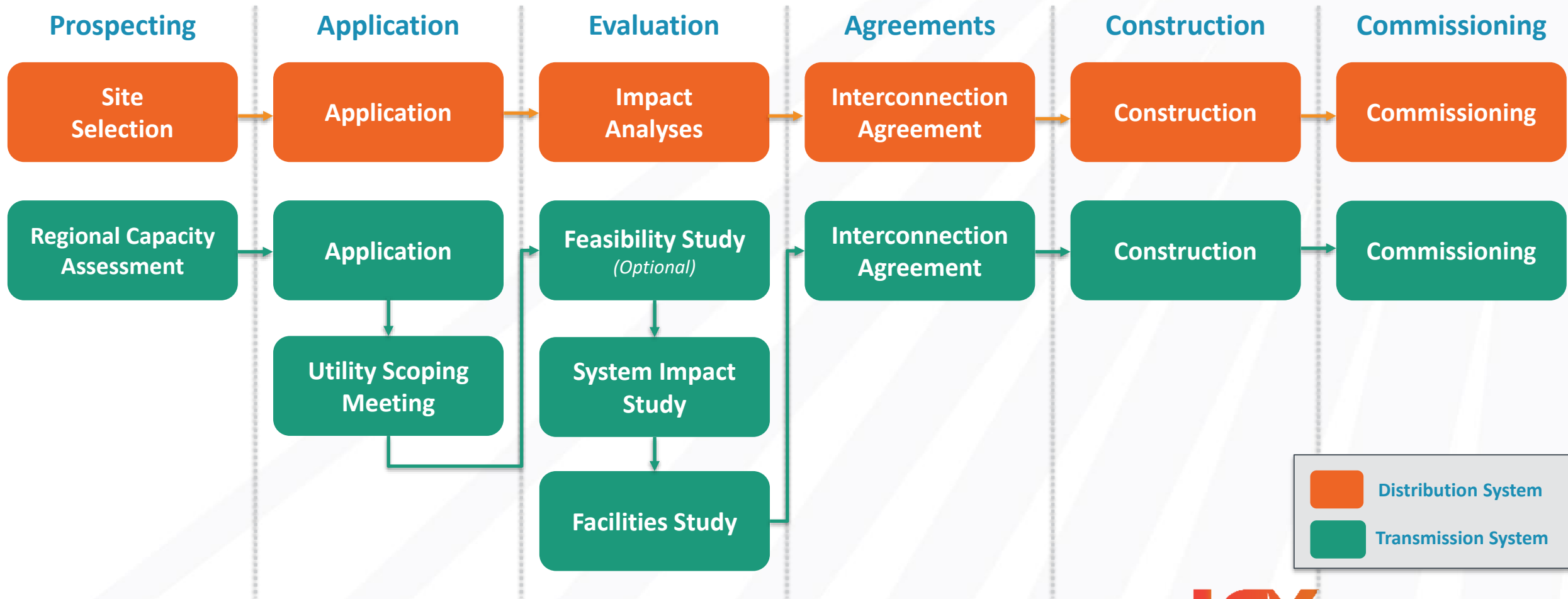
Enable new entrants with more
affordable access.
Diverse stakeholders required to
fully understand regulatory,
technical, and process



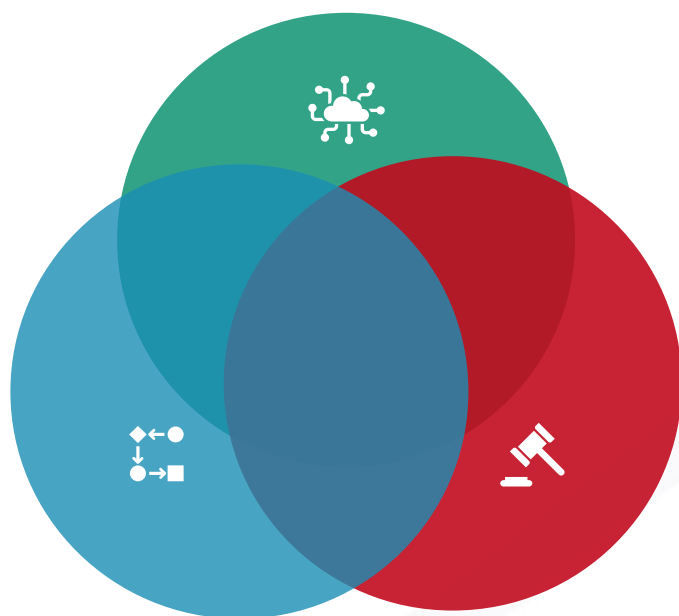
5x

Expected increase in the number of Solar & Wind
Deployments every year to meet 2035 targets

A Framework for Examining Interconnection



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

Greatest interconnection challenges

Limited Grid-
Capacity
Transparency

Lengthy Queue
Processing
Timelines

Lack of Fair Cost
Allocation
Procedures

High Impact Study
Costs

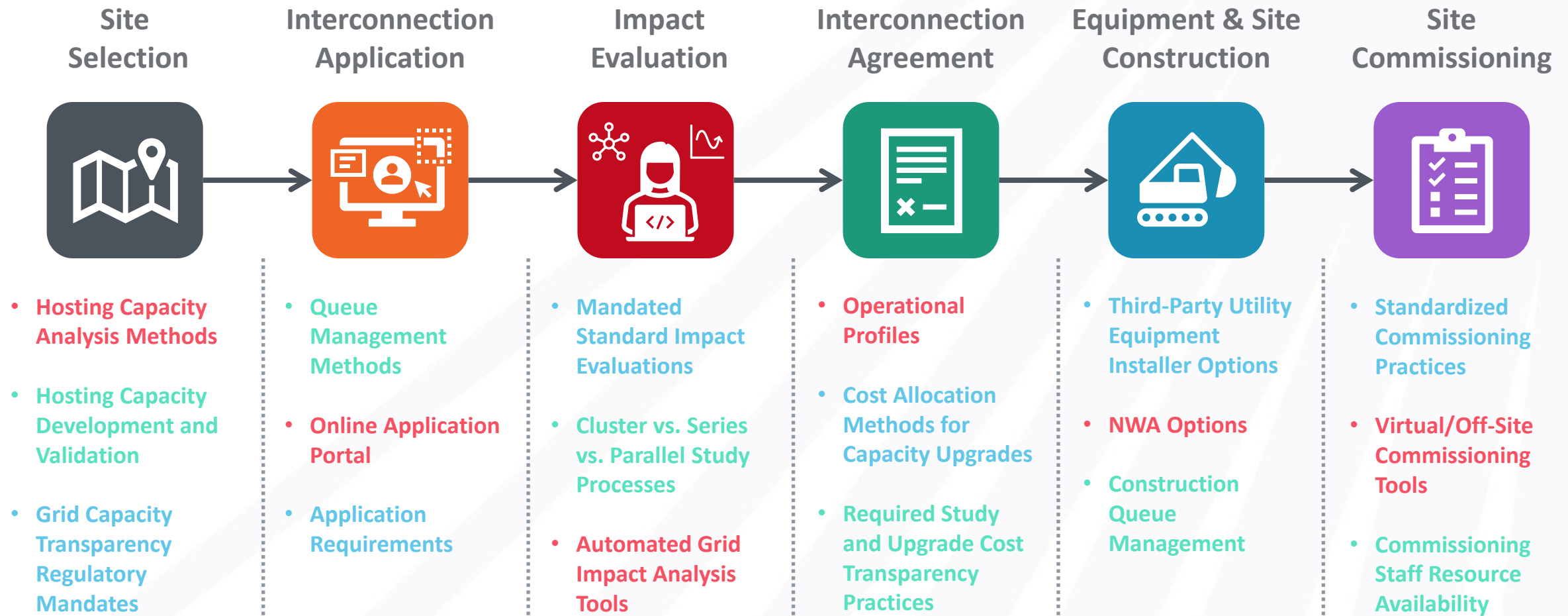
High Complexity of
Interconnection
Application

Uncertainty in Cost
of System
Upgrades

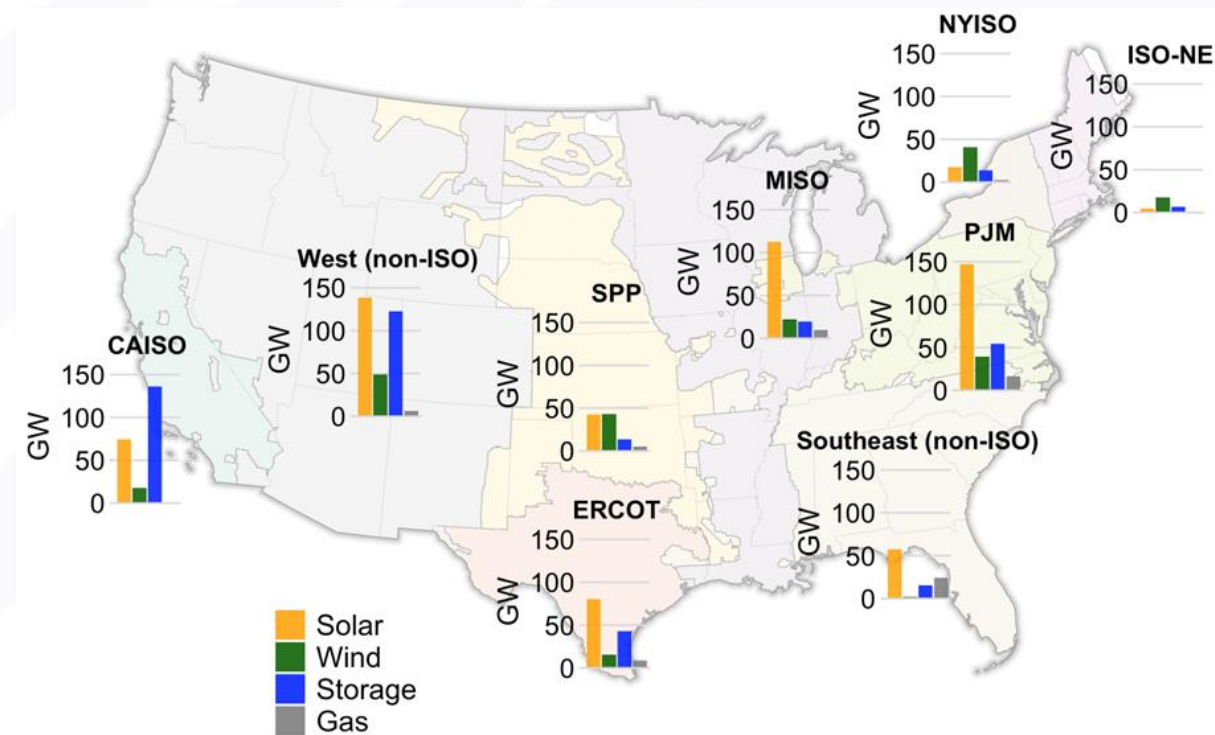
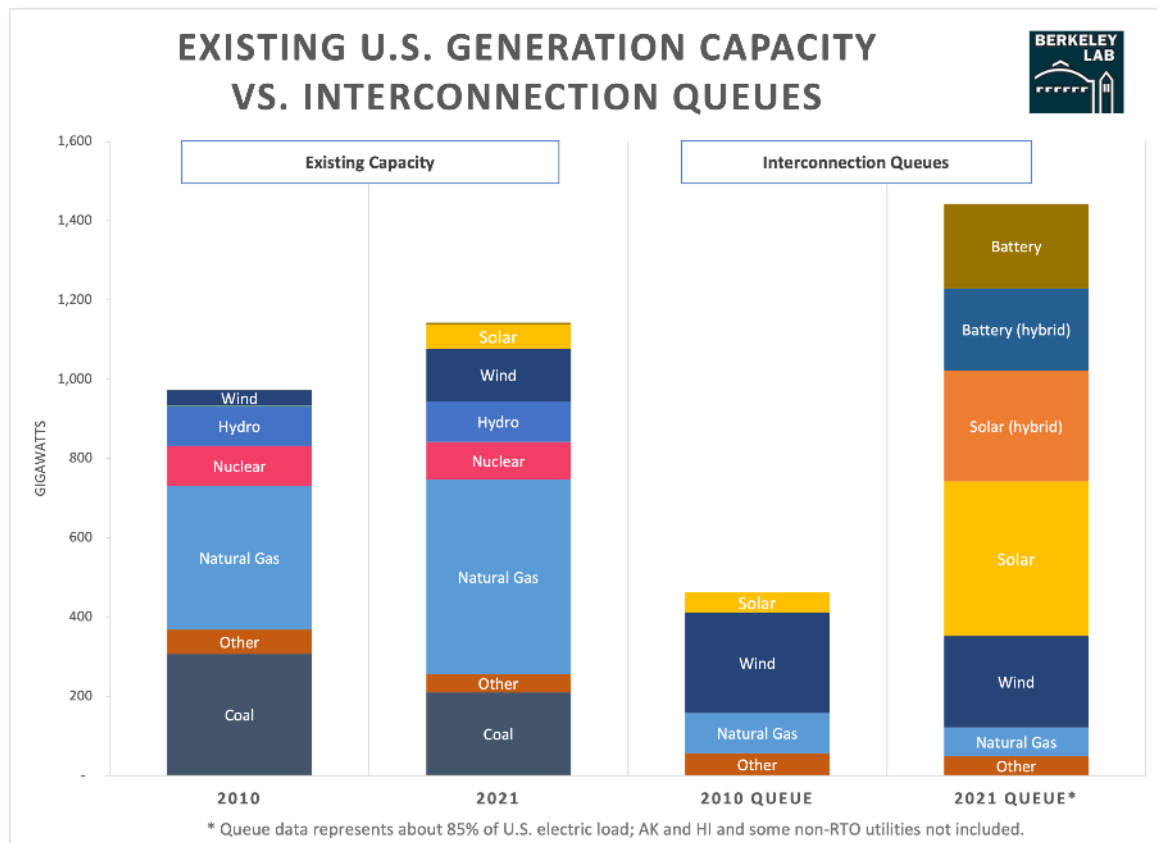
Multi-Study
Timeline
Coordination
Issues

- Lack of hosting capacity analysis or similar tools linking availability of land to available interconnection capacity.
- High integration cost that are inconsistent with project size.
- Slow and cumbersome interconnection process can lead to off-takers opting out of community solar.
- Misalignment of interconnection application requirements with ability to bid community solar projects – requirements modified.
- Regulatory restrictions on interconnection timeline ensuring operation within 12-months or less.

A Framework for Examining Interconnection



Status of Interconnection Queue



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



Government

State / Local / Federal / Tribal / Regulators / Agencies



Utilities

Investor-Owned / Public Power / Munis / Cooperatives



Grid Operators

Independent Service Operators (e.g. PJM, MISO, CAISO)



Non-Profits

Trade Groups / Energy Justice / Environmental Conservation

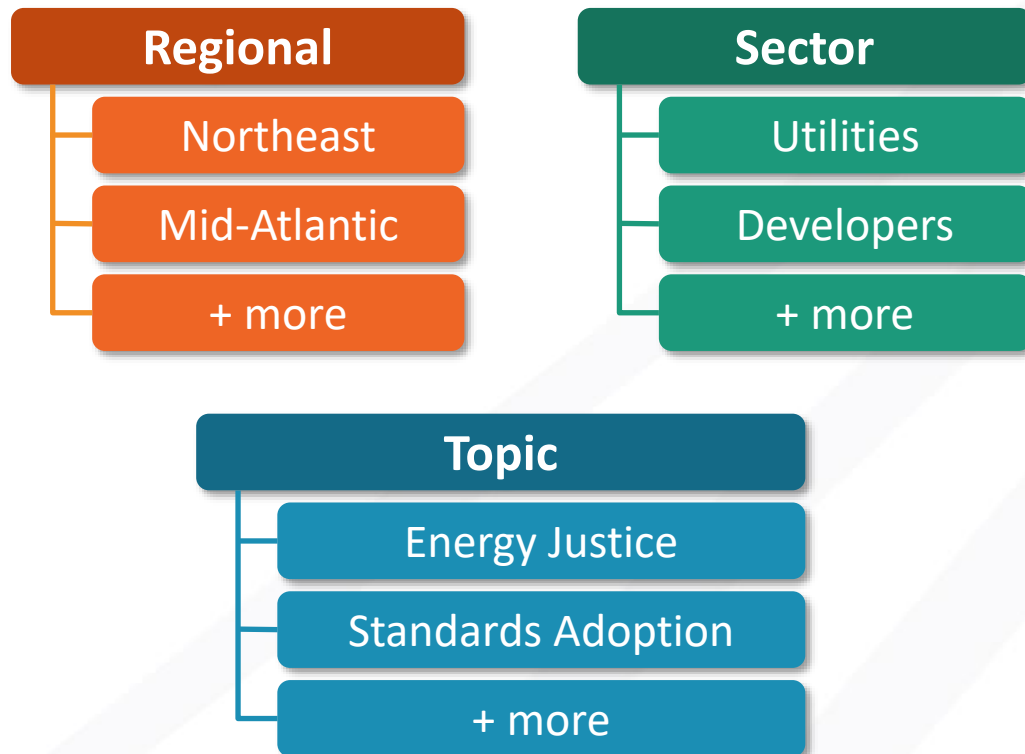


For-Profits

Developers / Consultants / Off-Takers / Solutions Providers

Engagement Mechanisms

Working Groups



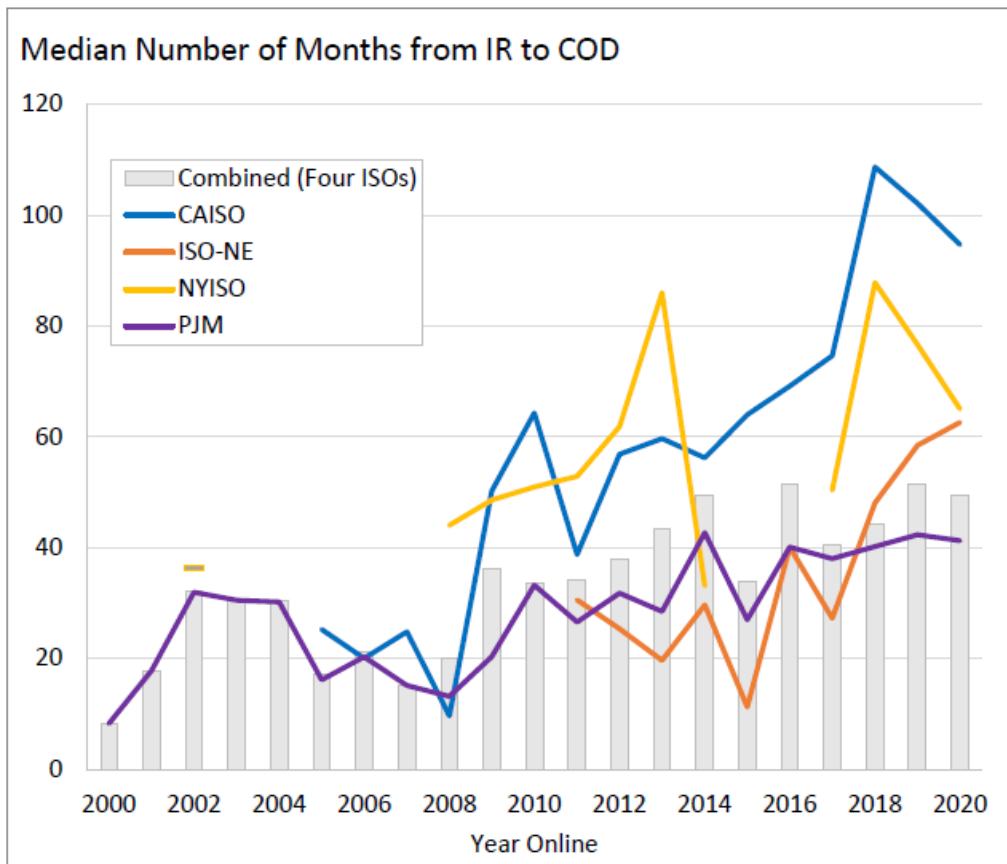
Engagement Platform



i2X Program Overview

Data Collection and Transparency

Completed Projects: Time in Queue, by ISO



Source: LBNL Queued Up 2.0 briefings

Increase the availability, transparency, and standardization of transmission data (interconnection queue timing and cost)

Gap in distribution data for the 50kW - 5MW PV scales (e.g., community solar projects)

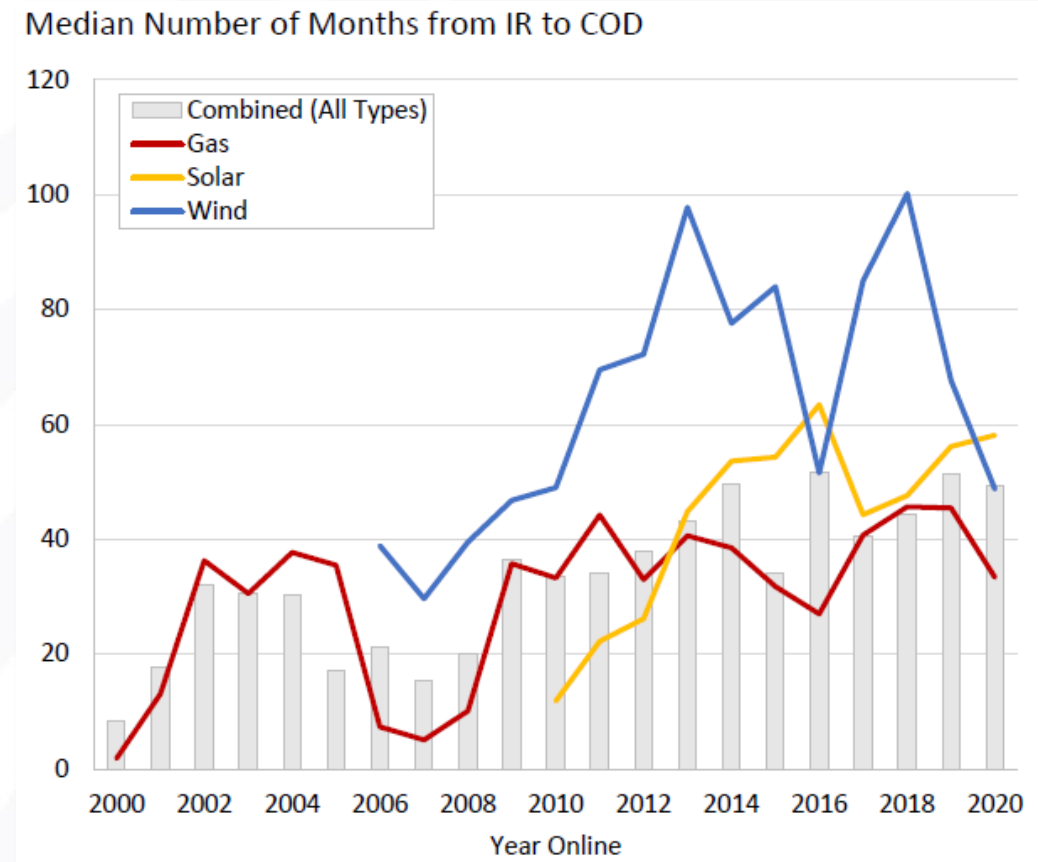
Data collection and transparency efforts limited by privacy and security concerns

i2X Program Overview

Transmission Analysis

Examples of Analysis:

- Industry survey on interconnection costs, delays, withdrawal reasons, etc
- Case studies and analysis of past, current, and proposed BPS interconnection queue reforms
- Assessment to determine if interconnection procedures are leading to higher-cost or lower-value renewable projects
- Examination of criteria and dispatch conditions for system stability
- Examination of the timing mismatch of detailed equipment models



Source: "Queued Up v2: Extended Analysis on Power Plants Seeking Transmission Interconnection as of the End of 2020" by J. Rand, W. Gorman, D. Millstein, A. Mills, J. Seel, and R. Wider at Lawrence Berkely National Laboratory presented to DOE-SETO in January 2022

Technical Assistance Opportunities

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

Implementing Queue
Management Methods

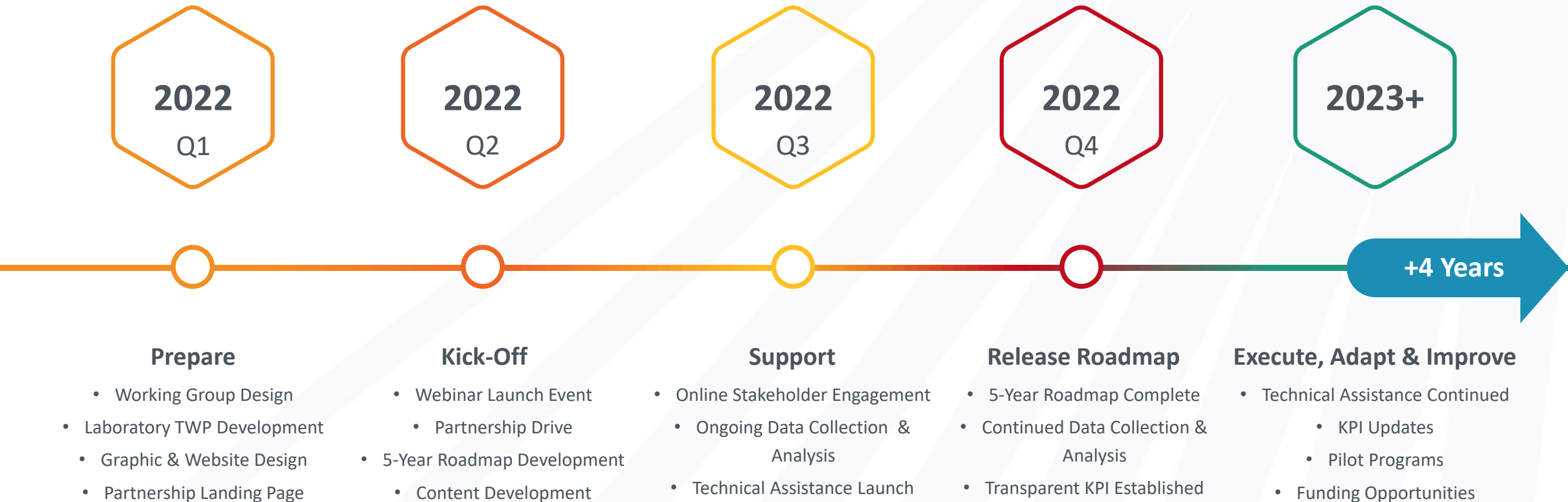
Accelerated Tool
Development and
Deployment

Direct Access to
Interconnection
Experts

Best Practices and
Training

i2X Program Overview

i2X Timeline



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



PARTICIPATE IN UPCOMING EVENTS

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

Join Our Growing List of i2X Partners!

- 8minute Solar Energy
- AC Power LLC
- Advanced Battery Concepts
- Alegna Technologies, Inc.
- Altitude Grid, LLC
- Amazon Web Services
- American Council on Renewable Energy
- American Microgrid Solutions
- American Renewable Energy Standards and Certification Association (ARESCA)
- AnnDyl Policy Group
- Appalachian Voices
- Audubon
- Black & Veatch
- Bob Wolfson Consulting
- BrightNight Energy
- Capstone Green Energy
- Center for Renewables Integration, Inc.
- ChargeNet Stations
- City of Los Angeles - Mayor's Office
- City of Santa Barbara
- Clean Catch Energy
- CleanTech Energy Solutions, Inc.
- Coalition for Community Solar Access (CCSA)
- Cold Volt
- Colorado Clean Transportation Coalition
- Community Renewable Energy
- Compass Energy Consulting
- Cornell University
- Cox Enterprises

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- Czero, Inc.
 - DAE Technologies, Inc.
 - Daheco Engines & Energy
 - Dividend Finance, Inc.
 - DRG Technical Solutions
 - Eastman Kodak Co
 - Ecogy Energy
 - EDP Renewables
 - Electric Power Energy LLC
 - Electric Power Research Institute (EPRI)
 - Elia Grid Inc
 - Elysian Co
 - Energy Inc
 - Energy Power
 - Enovation
 - Environmental
 - Environmental Work
 - EPC LLC
 - Exeter Associates, Inc.
 - Fluor Corporation
 - Flux XII LLC
 - Fusion Power Energy Systems
 - GE Research
 - GismoPower LLC
 - Green Energy Enterprise Ltd. (GEEL Power)
 - Green Lantern Development, LLC
 - Grid Strategies LLC
 - GridBright
 - GridUnity
 - Grow Greater Englewood
 - GRUPO ROCHA
 - GTI Energy

- IAEM
- ICE Thermal Harvesting
- Idaho National Laboratory
- InnoGrid
- Intengy Co, Inc.
- Iowa State University
- IPLC/Vantera www.pf-one.com
- Jacobs Engineering
- K&A Engineering Consulting
- K. R. Saline & Associates, PLC
- LADWP
- Lehigh University
- LineVision
- Longroad Energy
- Marathon Digital Holdings
- Marquette University
- Mercury Solars LLC
- Michigan Energy Innovation Business Council
- Midwest Agrivoltaic Systems LLC
- Midwest Climate Collaborative
- Mid-West Electric Consumers Association
- Modern Grid Solutions
- National Grid
- National Grid Partners
- Navia Energy Inc
- NERC
- NextEra Energy Resources, LLC
- Oak Ridge National Laboratory
- OATI
- Ostendo Technoogies
- Override Industries
- Pearl Street Technologies

- 380**

**Unique
Companies**

The infographic features a large green circle containing the number "380". To the right of the circle, the words "Unique Companies" are written vertically in white. Below the circle, the word "Solar" is written horizontally in white.

Solar industry companies listed:

 - PENNSYLVANIA SOLAR CENTER
 - Pepper Energy
 - Petrolern
 - Pine Gate Renewables
 - Pixida USA Inc.
 - Polaris Systems Optimization
 - power2Peer
 - PowerGrid Strategies, LLC
 - Prologia
 - PSG
 - Renaissance Consultants
 - Royal
 - School Star Energy Inc.
 - Self
 - Servicos Financeiro Power Industry
 - Sheehan Phinney Bass & Green
 - SISQ
 - SolarKal
 - SolarSCADA
 - Southern Renewable Energy Association
 - Southernstar
 - Stanford University
 - STATE GRID co China US office
 - Stem
 - Stevens Institute of Technology
 - Storke Renewables
 - Sun Tribe Development
 - Sundial Energy

- Sustainable Bitcoin Standard
- Sylvamo
- SynerGen Solar, LLC
- Synergics
- Texas A&M University
- Tom's Service
- TotalEnergies Renewables USA
- U.S. DOE
- Univeristy of New Mexico
- University of Alaska Fairbanks
- UT Austin
- Utah Office of Energy Development
- Utilidata. Inc.
- Virginia State Corporation Commission
- W International SC, LLC
- Wallaby Capital
- Wilson Sonsini Goodrich & Rosati, P.C.
- Xcel Energy Inc.

570

i2X Individual Partners

380

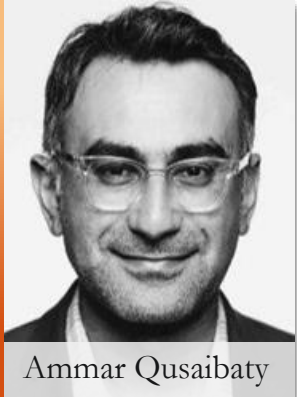
Unique Companies



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Leadership Team

SETO



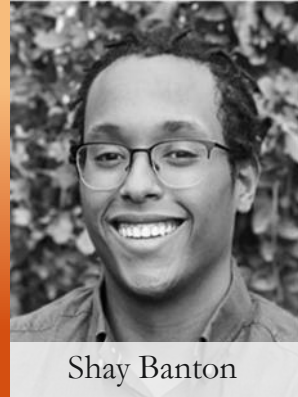
Ammar Qusaibaty

WETO



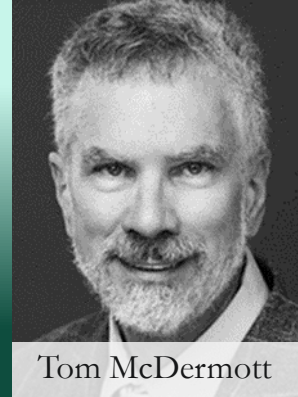
Cindy Bothwell

SETO



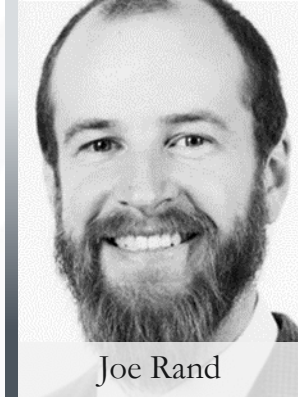
Shay Banton

PNNL



Tom McDermott

LBNL



Joe Rand

NREL



David Narang

SETO



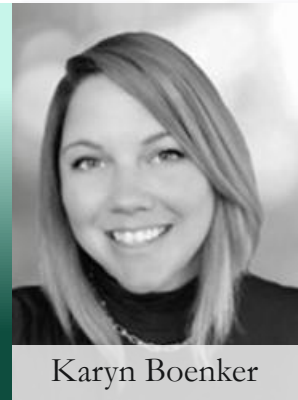
Michele Boyd

WETO



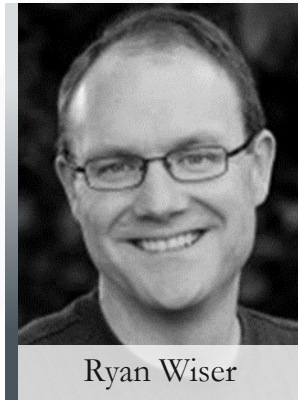
Jian Fu

PNNL



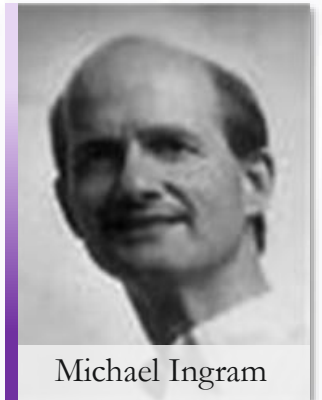
Karyn Boenker

LBNL

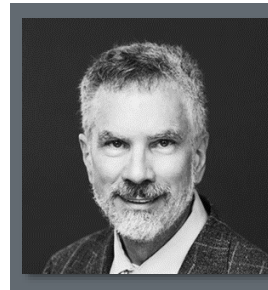


Ryan Wiser

NREL



Michael Ingram



Presenter

Tom McDermott

Chief Engineer & Solar Lead

Pacific Northwest National Lab

5-Year Strategic Roadmap

5-Year Strategic Interconnection Roadmap

50% cost and 50% schedule
reduction in 5 years

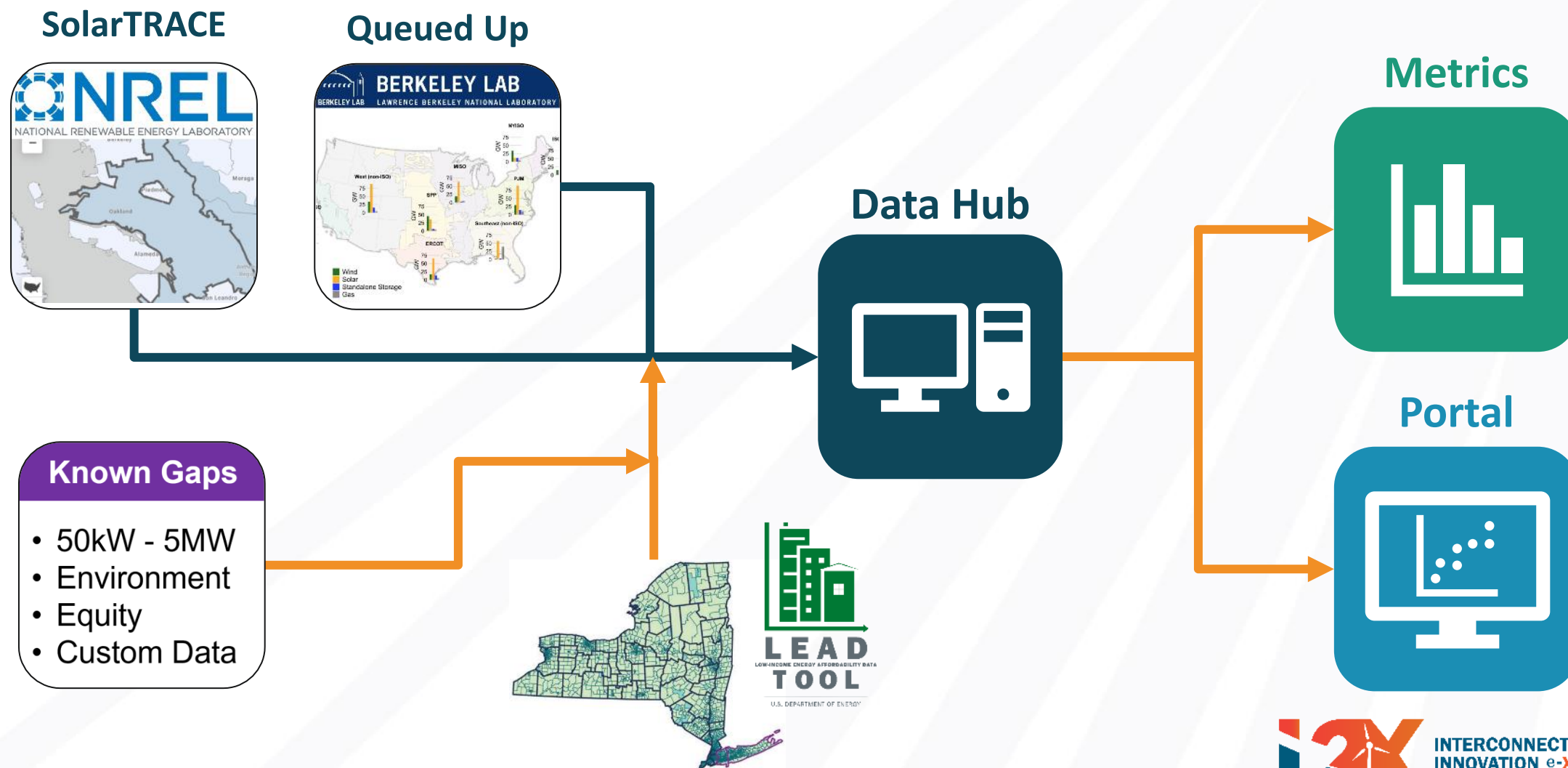
- Expert-Informed Goal Setting
- Success Milestones & Research Gaps
- Transparent Key Performance Indicators
- Customizations for Size and Region
- Transition Planning for New Processes
- Buy-in, Adoption, and Updates

Roadmap Outline

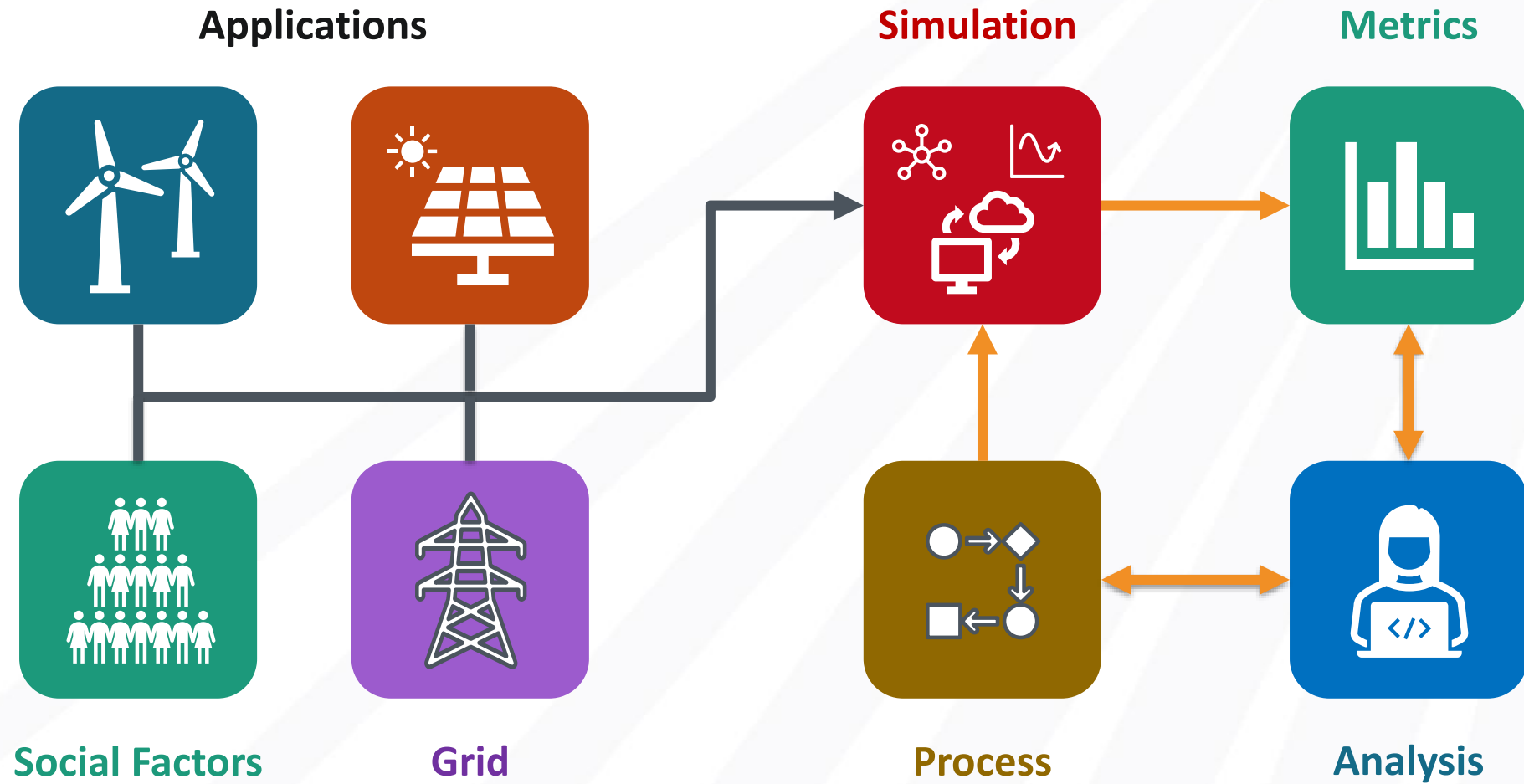
- Baseline for 2022, post-NOPR
- Discussion and justification of the 50% goal, and other new metrics for equity and environment
- Data collection plan; start-up and maintenance
- Sprint studies of better queue and alternative queue
- Model adoption language for new procedures
 - Include transitional periods
 - Include energy equity considerations beyond cost
- Pilots allowed within the FERC regulations
- Gaps in standards, regulations, and policies
- Yearly targets for metrics

* Interconnection study guidelines referenced as separate documents.

Filling Data Gaps to Support New Metrics



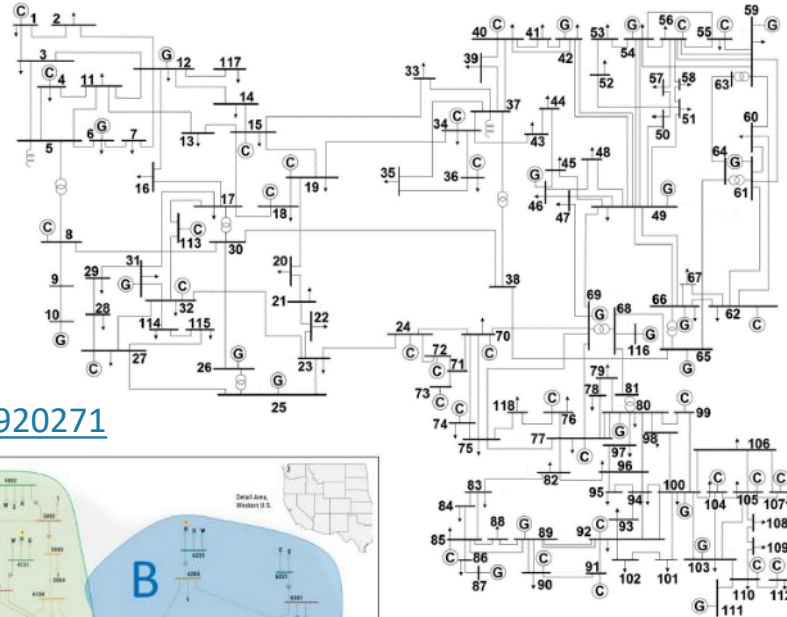
Sprint Studies with Public Data and Tools



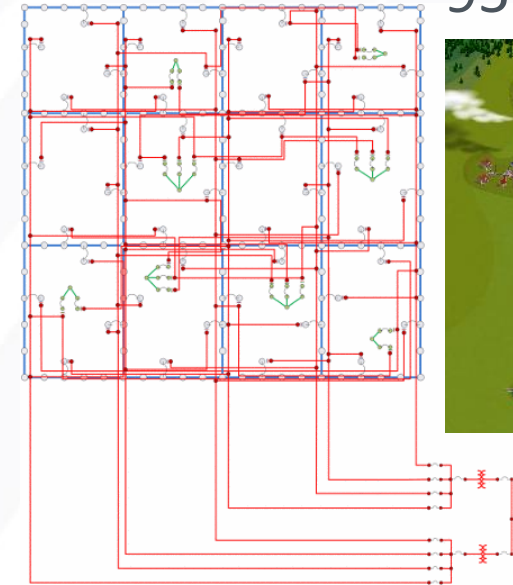
Public Test Systems for Replicability

IEEE 118-Bus with IBR

<https://doi.org/10.1109/TEMC.2019.2920271>

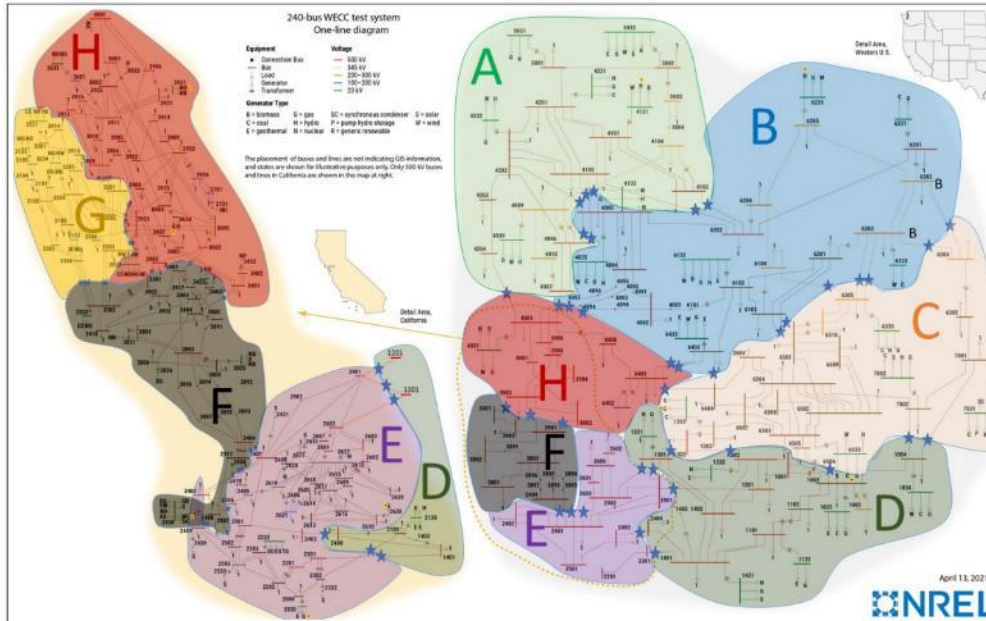


IEEE (proposed)
9500-node



IEEE Low-Voltage Network

<https://doi.org/10.1109/PESGM.2014.6939794>



energy.gov/i2x

WECC 240-Bus with IBR

<https://www.nrel.gov/docs/fy22osti/82287.pdf>

Technical Guide(s) to Interconnection Studies

Bulk Power Systems Guide

- Assumptions and Criteria
- Standards and Guidelines
- Data Collection
- When to use EMT Tools
- Model Development and Validation
- Analytical Steps and Automation
- Cluster Studies
- Re-study Criteria and Steps
- Post-Commissioning Models
- DER Aggregation
- Transmission Hosting Capacity
- Report Formats

Distribution System Guide

- Assumptions and Criteria
- Standards and Guidelines
- Data Collection
- When to use EMT (or Dynamics)
- Model Development and Validation
- Analytical Steps and Automation
- Hosting Capacity Studies
- DER Impact Studies
- Multi-DER (Feeder Cluster) Studies
- Influence of Storage and Chargers
- Report Formats



Two Sprint Studies with New Metrics

A Better Queue

- Assume clusters per NOPR
- Incorporate new equity metrics
- Shared costs of system upgrades
- Cluster formation and management options
- Model building improvements
- Tool and re-study automation

An Auction Process

- Discuss parallels to wideband spectrum auction
- Incorporate new equity metrics
- Identifying locations and quantities for new solar and wind resources
- Investing in renewable energy development zones (transmission)
- Requirements to participate
- Bid clearing mechanisms

Example: Model Adoption of 1547-2018 & 1547.1-2020

- Benefits of the base standard still leave some important choices open:
 - Gold: high-penetration DER; category III ride-through, category B for Q, island time 5 seconds
 - Silver: BPS reliability; category II ride-through, category A for Q, island time 3 seconds
 - Bronze: minimal pre-2018; category I ride-through, category A for Q, island time 2 seconds
- Role of communications
 - Protection-grade for direct transfer trip (DTT)
 - SCADA-grade for permissive anti-islanding
 - AMI-grade or SCADA-grade for dispatch and grid services; should consider a facility management system to handle communication failures (gap in 1547-2018)
- Communication standards – utility chooses SunSpec Modbus, IEEE 2030*, IEEE 1815 (DNP3)
- To justify DTT, perform a probabilistic risk assessment of unintended islanding greater than the 2-, 3-, or 5-second limit. Use 1-second load data. Consider permissive anti-islanding.
- Define any relevant edge cases, e.g., sub-transmission
- Which of these choices are regulatory? Which are left to the utility?
- Regulators could require the collection of interconnection process metrics for DER.

* Partially incorporates IEC 61850

Also see: <https://www.nrel.gov/grid/ieee-standard-1547/guide-to-updating-interconnection-rules.html>

Six Dimensions of Energy Equity

1. Access, e.g., eligibility for / participation in programs
2. Affordability, e.g., energy cost burden
3. Decarbonization, e.g., renewable energy target
4. Environmental Impact, e.g., air quality improvement
5. Resilience, e.g., sustained critical loads during extreme events
6. Social Impact, e.g., community ownership

Project Timeline

- August 2022 – Data and metrics plans, first technical assistance (TA) outline, sprint study outlines, roadmap outline.
- December 2022 – First TA study completed.
- March 2023 – Interconnection studies guide completed. Draft roadmap completed. New data sources stood up.
- June 2023 – Sprint studies and roadmap peer reviewed and published.
- September 2023 – Second round of TA studies completed.
- Ongoing – Friday i2X office hours, peer learning groups, working groups, other events



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INNOVATION e-XCHANGE**
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Thank You!

Website: energy.gov/i2X