Pennsylvania Energy Storage Consortium

MEETING #7

MARCH 22, 2023

Welcome & Overview

Mission Statement: To engage stakeholders on policy and market topics that identify the opportunities to deploy energy storage for a modern, resilient, cleaner, low-carbon grid for all Pennsylvanians.

Technical Notes:

- Please mute your mic/video unless indicated otherwise during Q&A.
- You may enlarge the presentation screen by going to the ellipses icon and clicking "focus on content" and/or "full screen."

Forum Overview:

- Access the PA DEP Energy Storage website.
  - Sign up for the Consortium mailing list.
  - Download the "Pennsylvania Energy Storage Assessment: Status, Barriers & Opportunities."
- The Steering Committee serves as content advisors.
- Past meetings have discussed the energy storage value proposition, opportunities for energy storage deployment in Pennsylvania, associated equity considerations, federal funding opportunities from the IIJA and IRA, and energy storage demonstrations.

Meeting Agenda

I. **Welcome & Overview**

II. **Interconnection Challenges, Best Practices, and Proposed Solutions**

   I. ***Barriers to Solar and Storage Interconnection*** **– Chirag Lala, Researcher, Applied Economics Clinic**

   II. ***Interconnection Policies to Enable the Flexibility of Energy Storage*** **– Brian Lydic, Chief Regulatory Engineer, Interstate Renewable Energy Council**

III. **Consortium Participant Updates**

IV. **Wrap-Up & Next Steps**

PENNSYLVANIA
ENERGY STORAGE
CONSORTIUM

Interconnection Challenges, Best Practices, and Proposed Solutions

Barriers to Solar and Storage Interconnection

Chirag Lala

Presentation to the Pennsylvania Energy Storage Consortium

Applied Economics Clinic

Upcoming report on behalf of Clean Energy Group

www.aeclinic.org

www.cleanegroup.org

March 22, 2022

Applied Economics Clinic

Economic and Policy Analysis of Energy, Environment and Equity

CleanEnergyGroup

Applied Economics Clinic

- Applied Economics Clinic (AEC) is a mission-based non-profit consulting group that offers expert services in the areas of energy, environment, consumer protection, and equity.
- AEC's clients are primarily public interest organizations—non-profits, government agencies, and green business associations—who work on issues related to AEC's areas of expertise.
- AEC works proactively to support and promote diversity in our areas of work by providing applied, on-the-job learning experiences to graduate students.
- AEC is committed to a just workplace that is diverse, pays a living wage, and is responsive to the needs of its eight full-time and seven part-time staff.

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

Clean Energy Group

Clean Energy Group (CEG) is a national nonprofit advocacy organization working to accelerate an equitable and inclusive transition to a resilient, sustainable, clean energy future. CEG fills a critical resource gap by advancing new clean energy initiatives and serving as a trusted source of technical expertise and independent analysis in support of underserved communities, nonprofit advocates, and government leaders working on the frontlines of climate change and the clean energy transition.

Clean Energy Group also manages and staffs the Clean Energy States Alliance (CESA), a national nonprofit coalition of state energy organizations working together to advance the rapid expansion of clean energy technologies and bring the benefits of clean energy to all.

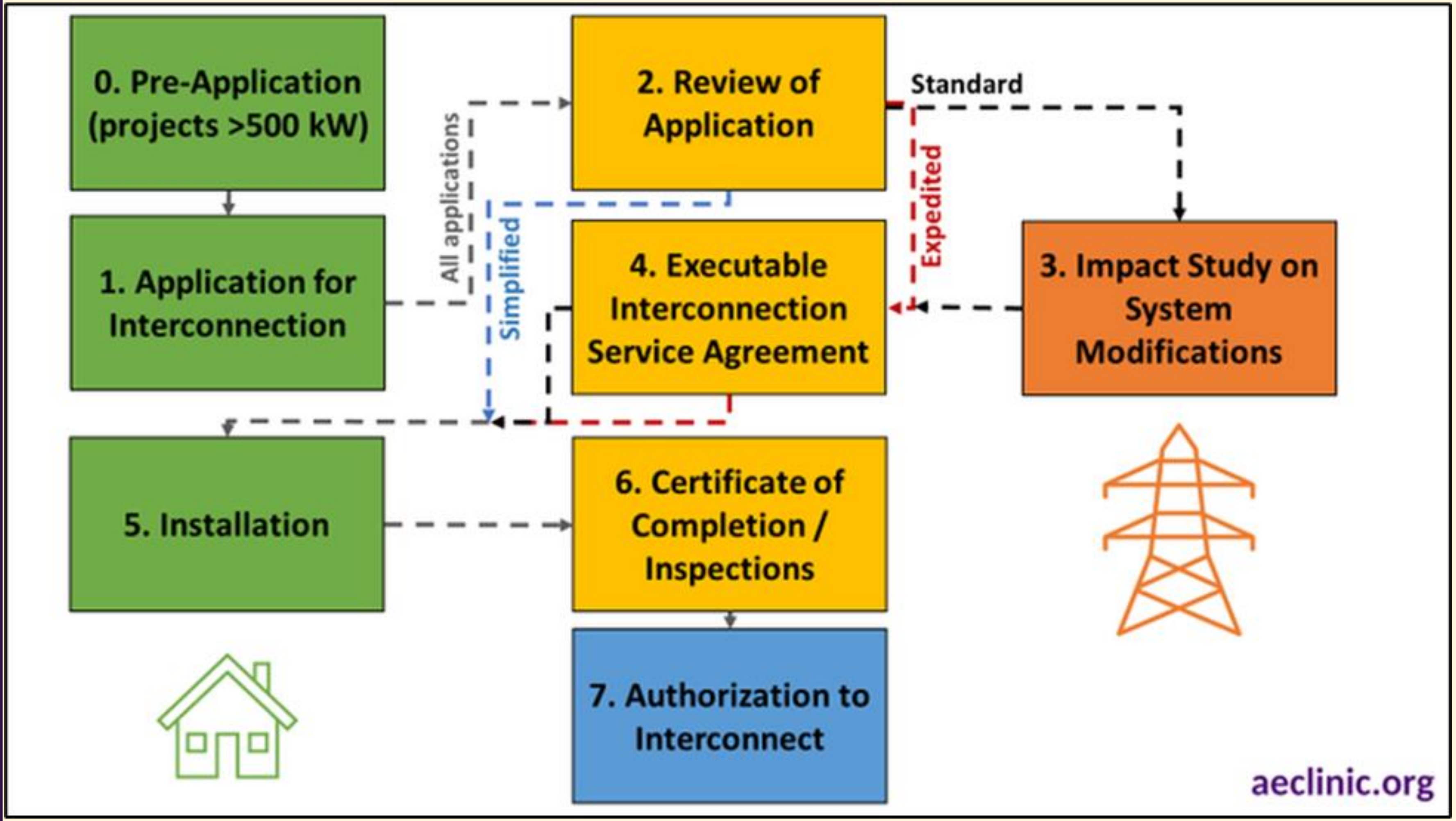
1) MA Interconnection Barriers Report on behalf of Clean Energy Group

1. Describe the interconnection process in MA
2. Document all major barriers to speedy project implementation
3. Investigate policies in other states
4. Assess the impact of those barriers on solar and storage projects, as well as the ability of states to meet their respective climate goals
5. Interviews

2) Interviews

- Insight into the four research questions: process, barriers, policies, and impact
- Experiences with the interconnection process
- Recommendations for additional research, areas of focus, or proposed changes to the process

3) Massachusetts interconnection process

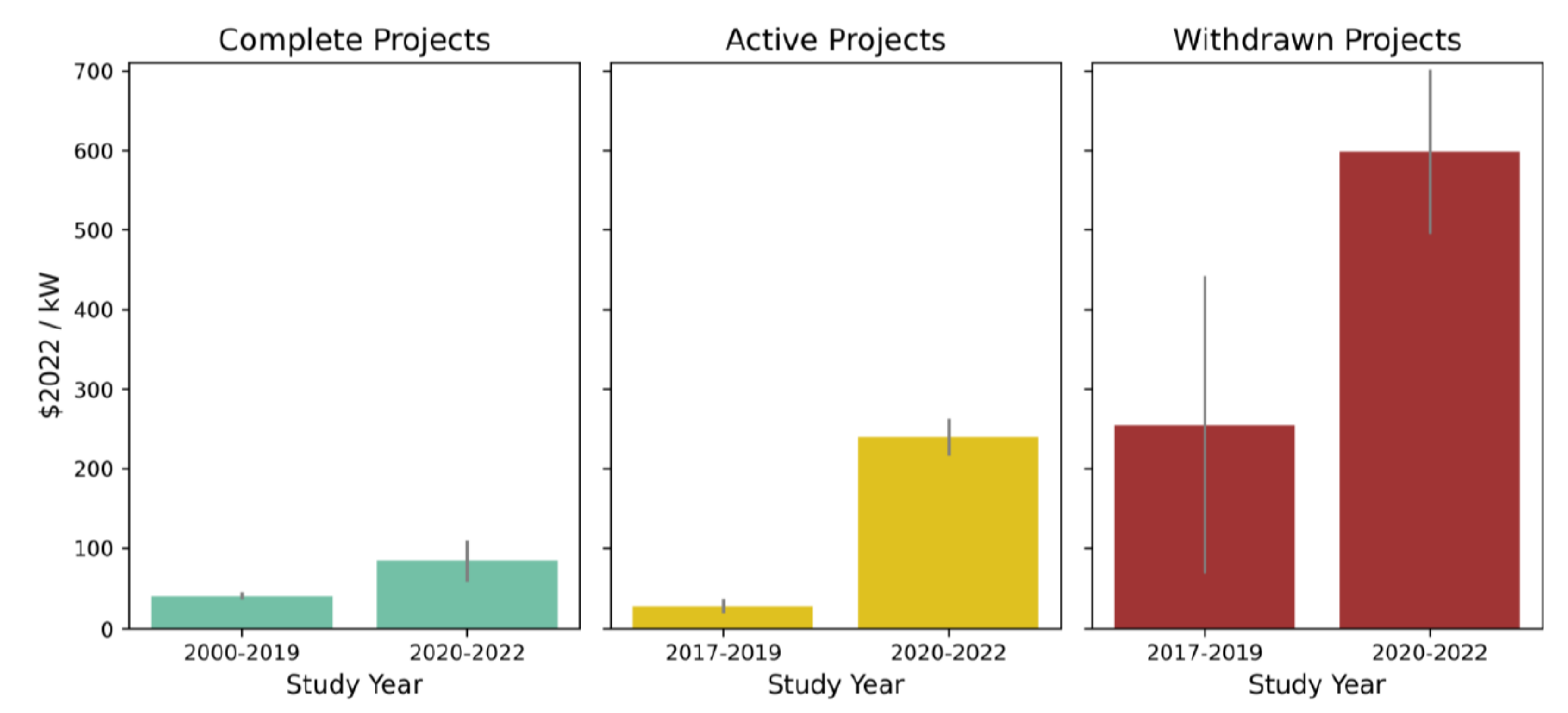


Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

4) PJM-specifics

- Average interconnection costs have grown
  - 2000-2009: $18-$30 $/kw median
  - 2010-2019: $8-$85 $/kw median
- Network upgrade costs drive increases
- Interconnection costs of storage, solar, wind (onshore and offshore) exceed those of natural gas from 2017-2022
- Interconnection queue doubled in capacity since 2019

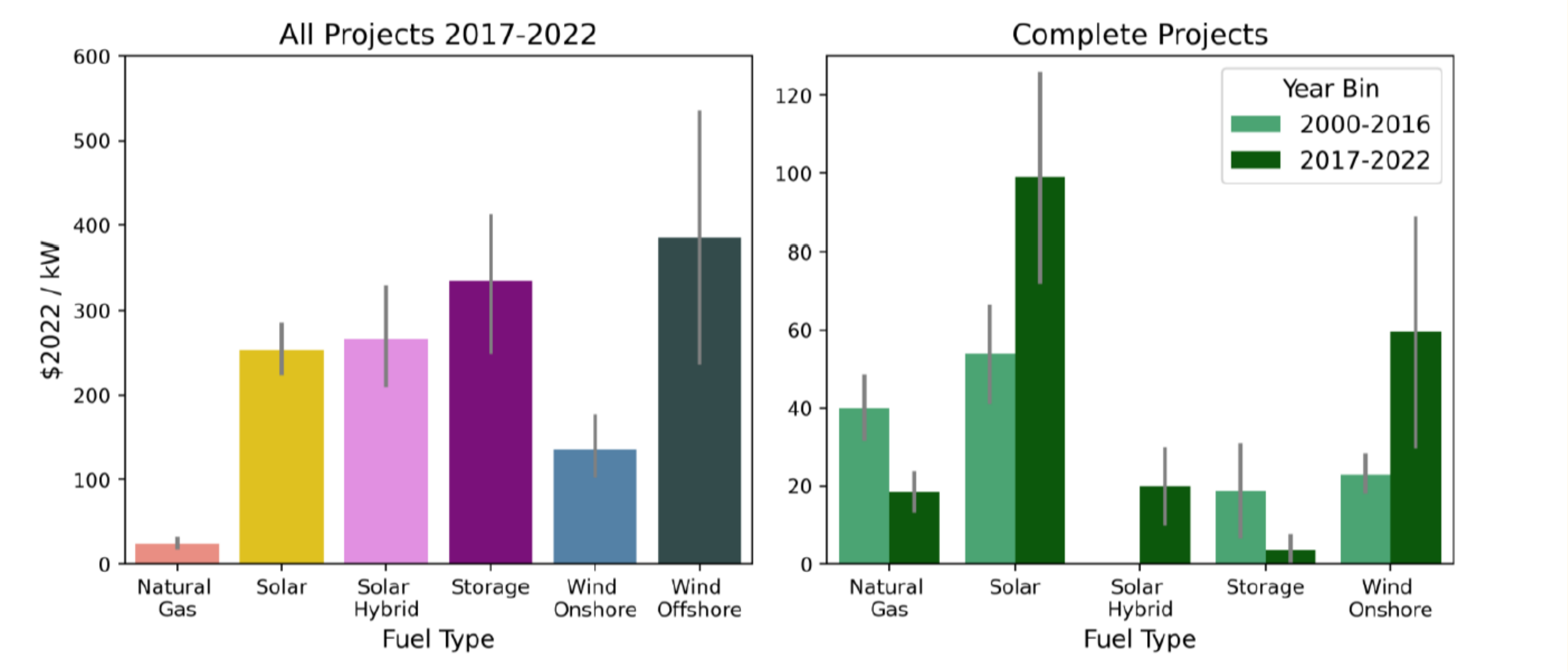
5) PJM Interconnection Costs by Request Status



Source: Figure 3 in Seel et al. 2023. Interconnection Cost Analysis in the PJM Territory. Berkeley Lab. Available at: https://eta-publications.lbl.gov/sites/default/files/berkeley_lab_2023.1.12-_pjm_interconnection_costs.pdf.

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

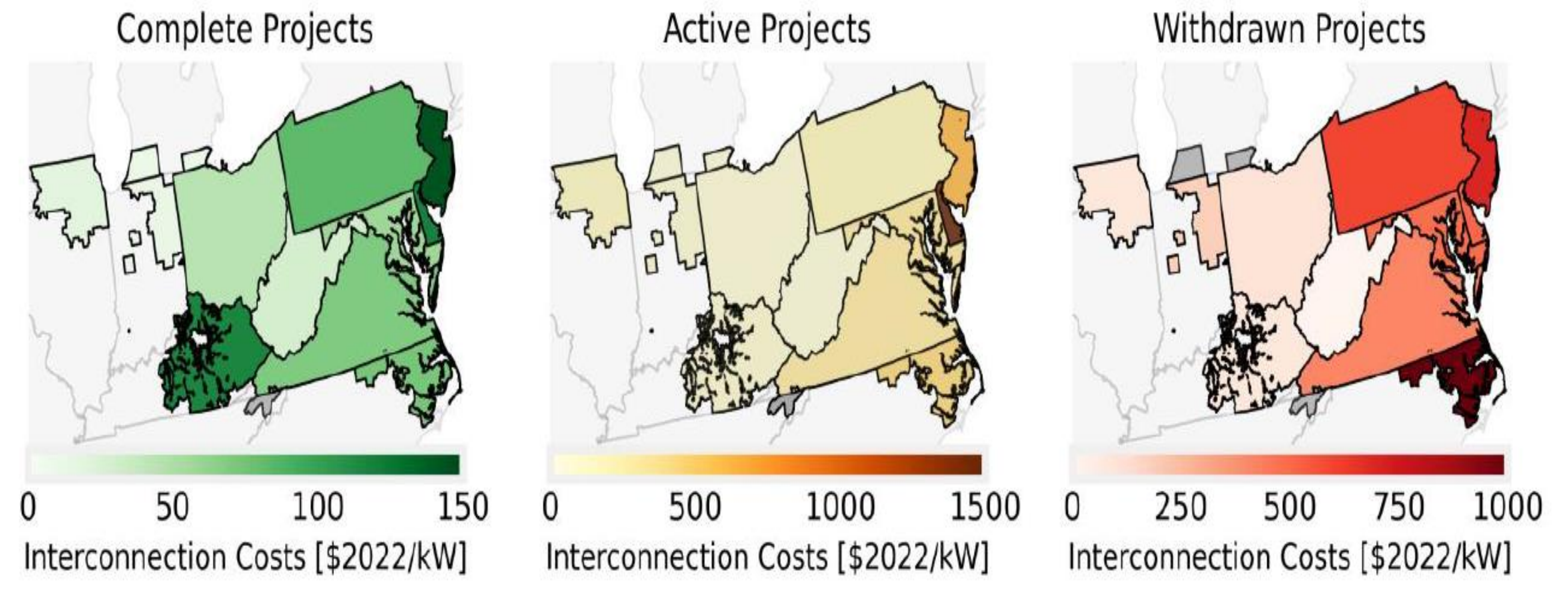
6) PJM Interconnection Costs by Fuel Type (left) and Over Time for Complete Projects (right)



Source: Figure 5 in Seel et al. 2023. Interconnection Cost Analysis in the PJM Territory. Berkeley Lab. Available at: https://eta-publications.lbl.gov/sites/default/files/berkeley_lab_2023.1.12-_pjm_interconnection_costs.pdf.

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

7) PJM Interconnection Costs by State and Request Status, all Fuel Types



Source: Figure 9 in Seel et al. 2023. Interconnection Cost Analysis in the PJM Territory. Berkeley Lab. Available at: https://eta-publications.lbl.gov/sites/default/files/berkeley_lab_2023.1.12-_pjm_interconnection_costs.pdf.

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

8) Cost causation

- Assigns the cost of infrastructure upgrades to the project whose application triggered the need to upgrade
  - Even if the upgrade benefits others
- Jockeying and delays in interconnection queues
  - Position in the queue is not outcome-neutral
- Project-dependent hosting capacity upgrades
- Disincentivizes planning by distribution utilities

9) Lack of planning for hosting capacity

- Planning for load vs. planning for bidirectional hosting capacity
- Reliance on individual projects
- No anticipation of future hosting capacity needs, target setting, or processes necessary to meet those targets
- Transmission capacity can ease some distribution system constraints

10) Project finances and costs

- How projects consider financing
  - Gains
  - Risks
  - Incorporated costs: modeling and process assumptions
- Barriers driving up interconnection costs
  - Lack of agreement between utilities and project applicants
  - Inflated modeling assumptions
  - High supply costs

11) Storage-specific barriers

- Lack of inclusion in interconnection rules
- Unreasonable assumptions about storage technologies
- No or scant mention of acceptable export-control technologies
- Non- and limited- export systems are assessed with unreasonable assumptions
- States have not updated interconnection rules to the most recent standards, do not provide sufficient information on the grid
- Utilities lack processes for evaluating operating schedules of storage
- Utility staff may not have the resources or expertise to assess or use export control technologies

12) Recommendation 1: Integrated planning

- Framework
  - Forecast DER growth
  - Estimate maximum potential of DER penetration given hosting capacity
  - Determine the available capacity left on the system
  - Plan hosting capacity upgrades based on anticipated DER growth
- Need for continuous iteration
- Connection to other interconnection solutions

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

13) Recommendation 2: Reforming cost causation

- Limitations of the cluster approach
- FERC 2022: *Improvements to Generator Interconnection Procedures*
  - 90 percent on MW basis and 10 percent on customer basis
- Post upgrade costs reimbursed to single entity
- NYSERDA's Cost Sharing 2.0: payment only for assigned distribution capacity
- Inclusion of ratepayers?
  - Advantage: spreading the benefits and planning incentives
  - Over-building concerns?

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

14) Recommendation 3: Storage solutions

- Define energy storage clearly
- Distinct screens for non-exporting projects
- Do NOT assume storage resources export full nameplate capacity. Calculate an export capacity based on steps taken to limit export
  - Embrace various standardized control methods and technologies
- Fast-track procedures for smaller systems
- Rules for inadvertent export
- Operational profiles

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

15) PJM DER interconnection proposals

- Reforms considered by Interconnection Process Reform Task Force (as of April 2022)
  - First-ready first-served basis
  - Costs based on the size of the project
  - Multiple project behind one POI treated as one
  - Early transition out of study process if no upgrades
- FERC-approved changes (late 2022)
  - Fast lane for 450 existing projects to clear blockages
  - Commercial readiness deposits and site control procedures
  - Studying cost responsibility of individual projects in a cluster
  - Expediting agreements for projects not requiring network upgrades

Thank you!

Chirag Lala, Researcher
1012 Massachusetts Avenue
Arlington, MA 02476
chirag.lala@aeclinic.org
(781) 819-4263

Sachin Peddada, Assistant Researcher
sachin.peddada@aeclinic.org
(617) 702-4650

Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

Interconnection Policies To Enable the Flexibility of Energy Storage

March 22, 2023

Brian Lydic
Chief Regulatory Engineer
Interstate Renewable Energy Council

IREC

We would like to thank the Department of Energy Solar Energy Technologies Office for supporting this project.

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 and Technologies Office Award Number DE-EE0009002. The views expressed herein do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

Interstate Renewable Energy Council (IREC)

IREC builds the foundation for rapid adoption of clean energy and energy efficiency to benefit people, the economy, and our planet.

BATRIES Project Team

BATRIES Project Snapshot

OBJECTIVE

Improve the interconnection process for storage and solar-plus-storage systems by reducing soft costs and increasing efficiency

OUTCOME

A nationally-applicable Toolkit of solutions for regulators, utilities, and storage developers

TIMEFRAME

3-year project

YEAR 1	YEAR 2	YEAR 3
ROADMAP	TOOLKIT	EDUCATION

Toolkit Solutions

STREAMLINE THE PROCESS

- Include storage in rules
- Improve evaluation of limited- and non-export systems
- Allow for project design changes during interconnection review
- Increase grid transparency

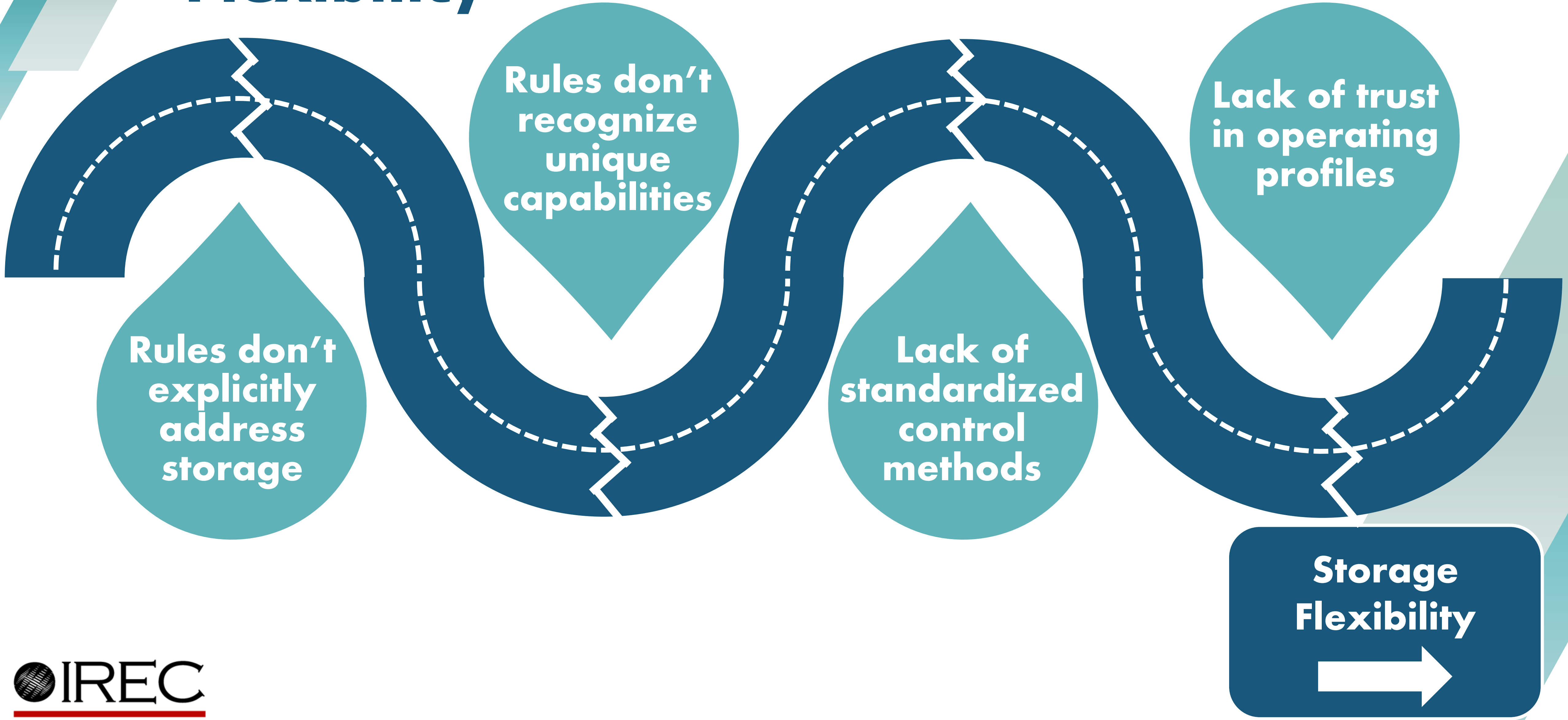
UNLOCK NEW CAPABILITIES

- Incorporate updated technical standards in rules and technical requirements
- Determine acceptable export control methods

IDENTIFY IMPACTS/OPPORTUNITIES

- Evaluate inadvertent export effects on the grid
- Define rules and processes for fixed schedule operation of a DER

Barriers to Enabling Energy Storage Flexibility



Lack of Trust in Controlled Exports

Difficult for Utilities to Trust That Storage Assets Will Operate as Described

Default Assumption That Systems Will Export Their Full Nameplate Capacity 24/7

How To Enable Export-Controlled Storage Systems

- Identify Acceptable Export Control Methods
- Update Screening/Study Processes to Account for Controls
- Allow for System Design Changes During Review

Limited-Export Storage

The exporting capability of a DER whose Generating Capacity is limited by the use of any configuration or operating mode [using any of the acceptable export control measures approved for use by that PUC]

IREC

New and Requires More Refined Approach

- The concept of limited export has challenged the existing frameworks for both all-export and non-export
- Puts the focus on refining the terminology for the "capacity" that will be evaluated for each technical criteria
- A handful of state rules now recognize limited export, but in most cases this is still limited to a static export value vs. one that is scheduled or dynamic.

Inadvertent Export

The unscheduled export of active power from a DER, exceeding a specified magnitude and for a limited duration, generally due to fluctuations in load-following behavior

Inadvertent Export Basics

- Non- or limited-export DERs may, in certain conditions, inadvertently output small amounts of power to the grid for short durations of time
- Most interconnection rules don't define how to evaluate inadvertent export
- Inadvertent export is distinct from a full export project and needs to be reviewed differently to avoid overstating impacts

How Interconnection Procedures Currently Address Controlled Export

- Type 1: Don’t recognize it (e.g., FERC SGIP)
- Type 2: Include some form of distinct review process, but usually don’t identify acceptable export control methods (e.g., Code of MD Regulations 20.50.09)
- Type 3: Include a distinct screen for export controls with more details on acceptable methods (e.g., CA Rule 21)

But note, most existing procedures address non-exporting systems only, and don’t address limited-export system interconnection

Solution: Identify Acceptable Export Control Methods

- It is important to identify acceptable export control methods:
  - Increases transparency, clarity, and predictability for utilities and interconnection applicants
  - Ensures utilities can provide reliable electricity (i.e., partly through reliable DER operation)
  - Provides interconnection customers with necessary information to design their projects *before* submitting an application

IREC

Types of Controls

- Traditional Controls
  - Relies on standard equipment and is typically used for larger systems
  - Protective Relays
  - Internal settings (such as through smart inverters)
  - Probabilistic methods
- Power Control Systems (UL 1741 CRD for PCS)

Solution: Update Screening/Study Processes to Account for Controls

- Toolkit Recommendations
  - Verify export control methods
  - Reflect export capacity within eligibility limits for the Fast Track and Simplified review processes
  - Modify certain screening and study processes to ensure export-controlled systems are accurately evaluated
  - Consider operating profiles within impact assessments

Screens in Which Export Capacity is Appropriate to Use When Assessing Impacts

- Screens that evaluate upstream thermal or voltage impacts can be applied using only export capacity, if a screen to address inadvertent export is added
  - Penetration screens – 15% and 100%
  - Shared secondary/transformer impact screen
  - Supplemental review of PQ and Safety need to consider export control

New Inadvertent Export Screen

2.2.1.3 For interconnections that can introduce Inadvertent Export (IE)* greater than 250 kW. The IE should not cause a change in medium voltage exceeding 3%. Voltage change will be estimated applying the following formula:

Formula	$$\frac{(R_{SOURCE} \times \Delta P) - (X_{SOURCE} \times \Delta Q)}{V^2}$$
Where: ΔP = (DER apparent power Nameplate Rating – Export Capacity) × PF, ΔQ = (DER apparent power Nameplate Rating – Export Capacity) × $\sqrt{(1 - PF^2)}$, R_{SOURCE} is the grid resistance, X_{SOURCE} is the grid reactance, V is the grid voltage, PF is the power factor	

* Calculated IE as the nameplate rating – export capacity

Current Process for Changing System Design During Interconnection Review

Customer submits application

Utility uses screen/study criteria to evaluate

If utility determines upgrades are needed

Typical options today

- Option 1: Customer pays for the upgrades
- Option 2: Customer withdraws, forfeit their place in queue, and submit a new design and application

Most states rules don’t include provisions for system design changes i.e., There is no place to allow for potential design changes to address screen results failure (We need **Option 3**)

Solution: Allow for System Design Modifications During the Review Process

SCREENING RESULTS SHOULD INCLUDE RELEVANT & USEFUL DATA

IMPACT STUDY RESULTS SHOULD INCLUDE ANALYSIS OF ALTERNATE OPTIONS

ALLOW FOR SYSTEM MODIFICATIONS DURING THE REVIEW & STUDY PROCESSES

Toolkit Chapters That Address Storage Flexibility

What we discussed during this webinar:

- Chapter III: Requirements for Limited- and Non-Export Controls
- Chapter IV: Evaluation of Non- and Limited-Export Systems During the Screening or Study Process
- Chapter VII: Pathways to Allow System Design Changes During the Interconnection Review Process to Mitigate the Need for Upgrades

IREC

To download the Toolkit, go to:

energystorageinterconnection.org

If you have any questions, contact:

Brian Lydic

Chief Regulatory Engineer| IREC

brian@irecusa.org

IREC

PENNSYLVANIA
ENERGY STORAGE
CONSORTIUM

Consortium Participant Updates

Wrap-Up & Next Steps

Next Energy Storage Consortium meeting:

Wednesday, May 24, from 1-3 ET

Provide Feedback: PA_energystorage@strategen.com

Appendix

Types of Controls

- Relays
  - Reverse power protection (device 32R)
  - Minimum power protection (device 32F)
  - Directional power protection (device 32)

Types of Controls

- Configured Power Rating
  - Internal setting (such as through smart inverter)
  - Used in the past but not certified
  - Now can be certified at inverter with IEEE 1547.1

IEEE Std 1547-2018 Nameplate Rating Parameter Name	IEEE Std 1547-2018 Nameplate Rating Parameter Label	Configuration Setting Parameter Name	Configuration Setting Parameter Label
Active power rating at unity power factor	NP_P_MAX	Active power rating at unity power factor applied setting	NP_P_MAX-AS
Active power rating at specified over-excited power factor	NP_P_MAX_OVER_PF	Active power rating at specified over-excited power factor applied setting	NP_P_MAX_OVER_PF-AS
Specified over-excited power factor	NP_OVER_PF	Specified over-excited power factor applied setting	NP_OVER_PF-AS
Active power rating at specified under-excited power factor	NP_P_MAX_UNDER_PF	Active power rating at specified under-excited power factor applied setting	NP_P_MAX_UNDER_PF-AS
Specified under-excited power factor	NP_UNDER_PF	Specified under-excited power factor applied setting	NP_UNDER_PF-AS
Apparent power maximum rating	NP_VA_MAX	Apparent power maximum rating applied setting	NP_VA_MAX-AS

Types of Controls

- Probabilistic Methods
  - Relies on nameplate power rating of DER to be small in comparison to load at the site
  - Example: "This option, when used, requires the nameplate rating of the DER to be so small in comparison to the Local EPS minimum load, that the use of additional protective functions is not required to ensure that power will not be exported to the Area EPS. This option requires the DER nameplate rating to be no greater than 50% of the Local EPS verifiable minimum over the past 12 months."

Inadvertent Export