IREC Presentation on Interconnection Best Practices

March 12, 2024

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IREC Presenters

Dave Golembeski

Senior Program Manager

Brian Lydic

Chief Regulatory Engineer

About the Interstate Renewable Energy Council

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

Agenda

- Overview of IREC's Freeing the Grid project and *Model Procedures*
- Opportunities for Improvement
  - 1547-2018 Adoption
  - Rule Applicability
  - Export Capacity
  - Initial Review Screens
  - Supplemental Review Screens
  - Data Sharing & Transparency
  - Upgrade Costs
- Recommendations Summary

What is Freeing the Grid?

Freeing the Grid is a joint initiative of IREC and Vote Solar that grades states on critical policies that help to increase clean energy adoption and access to the grid.

IREC → Interconnection Grades

VOTE SOLAR → Net Metering Grades

Interconnection Grades + Net Metering Grades → FREEING THE GRID — Freeingthegrid.org

Graded 37 states plus Washington, D.C. and Puerto Rico

Evaluated interconnection rules based on 56 scoring criteria

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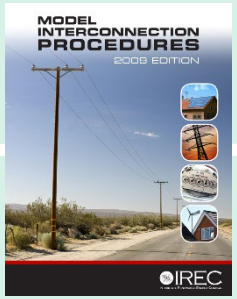
Overview of IREC's Model Interconnection Procedures

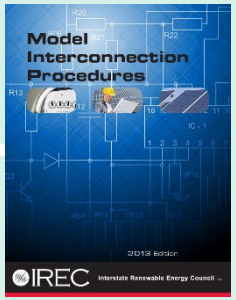
IREC's *Model Interconnection Procedures* reflect evolving best practices for interconnecting distributed energy resources to the grid in a manner that is fair, efficient, and maintains grid safety and reliability.

Updated Every 4-6 Years

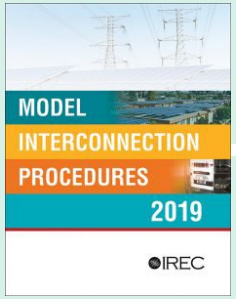
2005



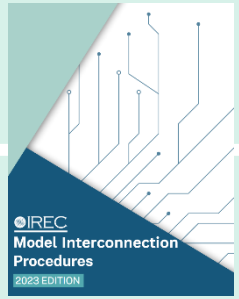
2009



2013



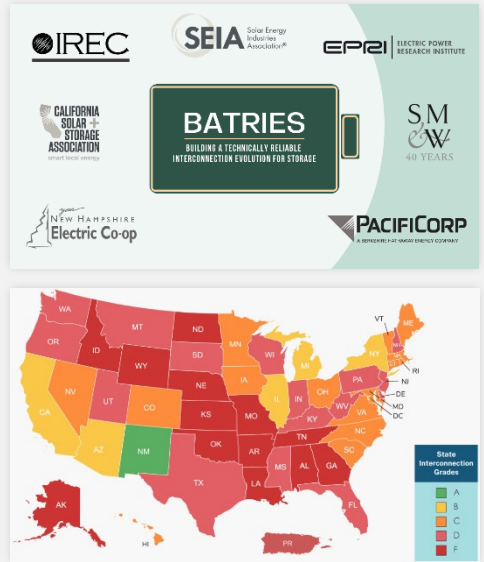
2019



2023

How Are They Developed?

State Regulatory Engagement



Collaborative Projects

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How to Use Freeing the Grid and the Model Procedures

Revisit your interconnection procedures regularly to ensure they are keeping up with evolving as well as emerging practices for streamlining grid connection processes.

Identify interconnection challenges, best practices, and opportunities for rule improvements

UT Rules

FTG

Use the model language in IREC's *Model Interconnection Procedures* to update your state's interconnection rules and practices

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BATRIES Project Snapshot

Objective

Reduce interconnection soft costs and time for distribution-connected standalone storage and solar-plus-storage projects by identifying and developing solutions to regulatory and technical storage interconnection barriers

Outcome

A nationally-applicable **Toolkit** of solutions for regulators, utilities, and storage developers, including model interconnection procedure language, that applies to diverse states and markets

Timeframe

3 years:

- Year 1: Produce a Roadmap to guide Toolkit development
- Year 2: Develop Toolkit
- Year 3: Training & Education of key stakeholders

To download the Toolkit, go to:

energystorageinterconnection.org

BATRIES Project Team

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EPRI | ELECTRIC POWER RESEARCH INSTITUTE

SM&W

SEIA Solar Energy Industries Association®

CALIFORNIA SOLAR + STORAGE ASSOCIATION
smart local energy

your New Hampshire Electric Co-op

PACIFICORP
A BERKSHIRE HATHAWAY ENERGY COMPANY

IEEE 1547-2018 Adoption

IREC has developed two IEEE 1547-2018 resources that can help stakeholders understand the policy considerations related to the Standard and streamline the adoption process.

IEEE 1547-2018 Implementation

Technical

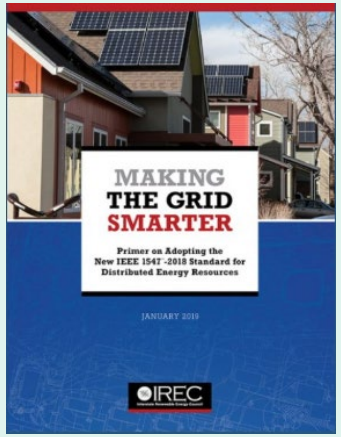
Time-Intensive

Many Decision Points

IREC IEEE 1547-2018 Resources

Topic	What to Consider	Decision Option (DO) Description	Utilize?
	A. Near Term		
Adoption timeline	Equipment listing to UL 1741 SB certifies conformance with 1547-2018 for inverter-based resources and some other interconnection equipment. Consider certified equipment availability, the use of UL 1741 SA certification in the interim (if needed), and whether naming a certain date is necessary before certified equipment is widely available. Compliance requirements are usually based on the interconnection application submission date. Some projects have long interconnection review and lead times and may not be installed until long after the application date. A mechanism to require some of those projects with earlier application dates to be 1547-2018 compliant once installed could be beneficial for grid support. Installed MW with 1547-2018 compliance could be increased if compliance is based on installation date. However, this may be challenging for developers from a planning perspective, as they may have to specify equipment that is not yet certified for 1547-2018. This issue may be mitigated if UL 1741 SA compliant inverters are utilized, which can have similar features as those required by UL 1741 SB/1547-2018. Also consider how an interim adoption period will be implemented, allowing for 1547-2018 compliance before the deadline. Widely available UL 1741 SB certified equipment is expected on the market by around April 2023 (dependent on several factors). More information is available on IREC's research on equipment availability.[2] [MTGS II]	**DO 1a-1:** Comply with IEEE 1547-2018 beginning [some date before April 1, 2023].	☐
		DO 1a-2: Comply with IEEE 1547-2018 beginning ~April 1, 2023 or a later date.	☐
		DO 1a-3: Comply with IEEE 1547-2018 when the equipment is readily available (TBD by Commission action).	☐
		DO 1b-1: Base compliance date on application submission date.	☐
		DO 1b-2: Base compliance date on installation date (may be useful for larger projects with long lead times).	☐
		DO 1b-3: Differentiate compliance date mechanism between smaller and larger projects.	☐
		DO 1c-1: Allow interim compliance with IEEE 1547-2018 beginning immediately.	☐
		DO 1c-2: Define another interim compliance pathway.	☐
Abnormal operating performance category	Consider input from transmission operators or regional reliability coordinator when assigning ride-through categories, plus local distribution utility protection practice. Since there can be conflict between distribution utility desires and bulk system reliability, 1547-2018 designates oversight of this selection to the Authority Governing Interconnection Requirements—often the Public Utilities Commission. [MTGS V.A]	**DO 2-1:** IEEE 1547-2018 Category III Ride-Through capabilities must be supported for inverter-based DERs. Rotating DERs must meet Category I Ride-Through capabilities, at minimum.	☐
		DO 2-2: IEEE 1547-2018 Category II Ride-Through capabilities must be supported by inverter-based DERs, at minimum. Rotating DERs must meet Category I Ride-Through capabilities, at minimum.	☐

Decision Options Matrix for IEEE 1547-2018 Adoption



Making the Grid Smarter: Primer on Adopting the New IEEE 1547-2018 Standard

Go to irecusa.org

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1547-2018 Adoption

Opportunities for Improvement

1547-2018 Adoption

RECOMMENDATIONS

Identify a date by which DER projects must comply with IEEE 1547-2018

Define categories and certification requirements

Identify or reference technical requirements and settings (incl. Commission oversight)

2023 *Model Interconnection Procedures*

IEEE 1547-2018 Compliance Date: Section IV.A.1
Technical Requirements: Section IV.A and Attachment 9

Adopting IEEE 1547-2018 – Key Considerations

- ❑ Determine timeline for implementation
- ❑ Where will the technical requirements reside?
- ❑ Choose categories
- ❑ Define default function and settings (or not)
- ❑ Voltage regulation impacts (volt-var, volt-watt)
- ❑ Process updates (mitigations, settings changes/selection)
- ❑ Interconnection Agreements
- ❑ Interconnection screens and study
- ❑ Communications (capability vs. utilization, pathways, protocols)

IREC's IEEE 1547-2018 Decision Option Matrix

Key:

Suggested for TIR	Original color
Suggested for Rule	
Rule or TIR	
Other	

			Decisions To make	
	Topic	**What to consider?**	**Decision Option (DO) Description**	**Utilize?**
Near Term	Adoption timeline	Consider equipment availability, the use of UL 1741 SA certification in the interim (if needed), and whether naming a date is necessary. Compliance requirements are usually based on the interconnection application submission date. Some projects have long interconnection review and lead times and may not be installed long after the application date. A mechanism to require some of those projects with earlier application dates to be 1547-2018 compliant once installed could be beneficial for grid support. Installed MW with 1547-2018 compliance could be increased if compliance is based on installation date, but this may be challenging for developers from a planning perspective, as they may have to specify equipment that is not yet certified for 1547-2018. This issue may be mitigated if UL 1741 SA inverters are utilized, which can have similar features as those required by UL 1741 SB/1547-2018. Also consider how an interim adoption period will be implemented, allowing for 1547-2018 compliance before the deadline. Widely available UL 1741 SB certified equipment is expected on the market by around April 1, 2023.	**DO 1a-1:** Comply with IEEE 1547-2018 beginning [some date before April 1, 2023].	☐
			DO 1a-2: Comply with IEEE 1547-2018 beginning ~April 1st, 2023.	☒
			DO 1a-3: Comply with IEEE 1547-2018 when the equipment is readily available (TBD by Commission action).	☐
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			DO 1b-2: Base compliance date on installation (may be useful for larger projects with long lead times).	☐
			DO 1b-3: Differentiate compliance date mechanism between smaller and larger projects.	☐
			DO 1c-1: Allow interim compliance with IEEE 1547-2018 beginning April 1, 2022.	☐
			DO 1c-2: Define another interim compliance pathway.	☐
	Abnormal operating performance category	Consider input from transmission operators or regional reliability coordinator when assigning ride-through categories, plus local distribution utility protection practice. Since there can be conflict between distribution utility desires and bulk system reliability, 1547-2018 designates oversight of this selection to the Authority Governing Interconnection Requirements – often the Public Utilities Commission.	**DO 2-1:** IEEE 1547-2018 Category III Ride-Through capabilities must be supported for inverter-based DER. Rotating DER must meet Category I Ride-Through capabilities.	☒
			DO 2-2: IEEE 1547-2018 Category II Ride-Through capabilities must be supported for inverter-based DER. Rotating DER must meet Category I Ride-Through capabilities.	☐
	Normal operating performance category	The selection of A or B will impact the use of voltage regulation controls. Some DER types cannot meet the full scale of reactive power support. Consider specifying category assignment based on technology type.	**DO 3-1:** Inverter-based DER shall meet reactive power requirements with 1547-2018 Category B. Rotating DER must meet Category A.	☒
			DO 3-2: All DER types (Inverter-based and rotating) shall meet reactive power requirements with 1547-2018 Category A.	☐

Abnormal Category

First, select one of two options

- Category III Ride-Through capabilities must be supported for inverter-based DER. Rotating DER must meet Category I Ride-Through capabilities, at minimum
- Category II Ride-Through capabilities must be supported by inverter-based DER, at minimum. Rotating DER must meet Category I Ride-Through capabilities, at minimum

Then, decide on trip settings

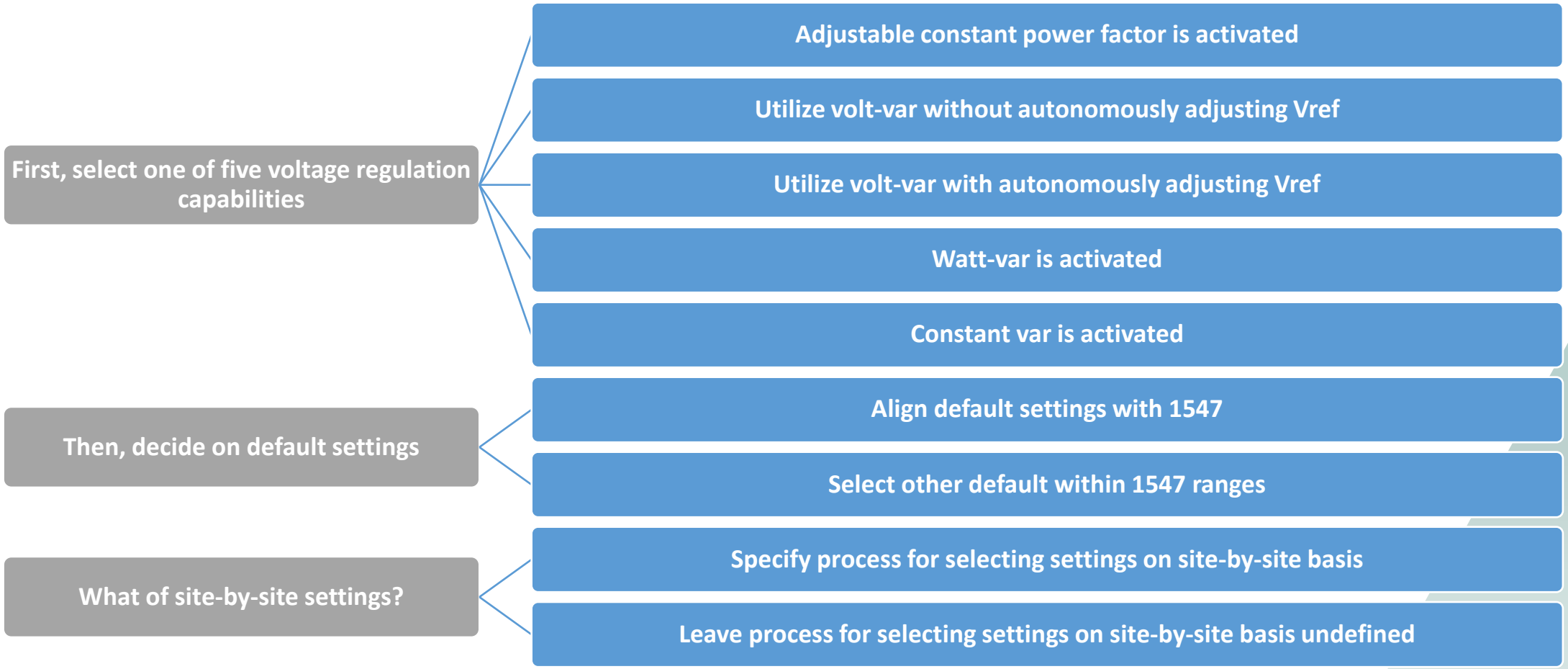
- Align default settings with 1547
- Select other default within 1547 ranges

Normal Category

Select one of two options

- Inverter-based DER shall meet reactive power requirements of 1547-2018 Category B. Rotating DER must meet Category A, and may meet Category B
- All DER types (inverter-based and rotating) shall meet reactive power requirements of 1547-2018 Category A, and may meet Category B.

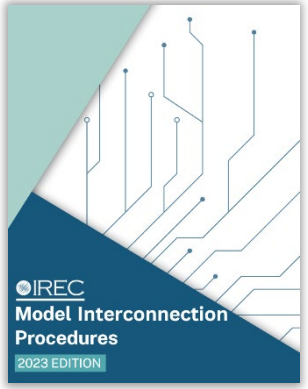
Voltage Regulation



IEEE 1547-2018 Incorporation Into Rules

IREC's 2023 *Model Interconnection Procedures* provide new guidance for clearly defining technical requirements and settings in interconnection rules and technical documents.

The new model language and template offer frameworks for clarifying technical requirements to help increase efficiency, minimize confusion, and reduce costs.



1. Beginning on *[insert effective date]* DERs shall be required to comply with IEEE Std 1547-2018, and shall conform with the following minimum requirements:

   a. Abnormal operating performance category: Inverter-based DERs shall meet Category III capabilities and rotating DERs shall meet Category I capabilities.

   b. Normal operating performance category: Inverter-based DERs shall meet Category B capabilities and rotating DERs shall meet Category A capabilities.

   Inverter-based interconnection equipment may be Certified to UL 1741 Third Edition, Supplement SB in order to demonstrate compliance with IEEE Std 1541-2018. Equipment that is not Certified to Supplement SB may require additional evaluation and commissioning testing to confirm compliance with IEEE Std 1547-2018.

Model language included in Section IV.A

Attachment 9
Technical Interconnection and Interoperability Requirements (TIIR) Template

Minimum Performance Requirements Based on DER Technology:

DERs shall conform with the following minimum performance requirements of IEEE Std 1547™-2018.

Normal and abnormal operating performance requirements based on technology type:

Technology	Normal Operating Performance Category	Abnormal Operating Performance Category
Inverter-Based DER	Category B	Category III
Rotating DER	Category A	Category I

Template included in Attachment 9

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Rule Applicability

Opportunities for Improvement

Rule Applicability

RECOMMENDATIONS

Explicitly incorporate energy storage as an eligible technology in the state's rules

2023 *Model Interconnection Procedures*
Section I.B.12 and 15 (Definitions)

"Distributed Energy Resource" or "DER" means the equipment used by an Interconnection Customer to generate, store, manage, interconnect, and monitor electricity.
For the purposes of these Procedures, an Energy Storage Device can be considered a DER or generator.

Export Capacity

Current Default Assumption

- Despite storage's flexibility, utilities generally assume that a system will export at 100% nameplate capacity, 100% of the time.

Opportunities for Improvement

Export Capacity

RECOMMENDATIONS

Define both “nameplate rating” and “export capacity”

Identify acceptable export control methods, including Power Control Systems

Allow certified inverter-based systems up to 50 kW with an export capacity of 25 kW or higher to be eligible for the Simplified (Level 1) Process without additional review

Base Fast Track (Level 2) Process eligibility on export capacity

2023 *Model Interconnection Procedures*	Definitions: Section I.B.16 (export) and 35 (nameplate) Export Control: Section IV.B.3 Technical Requirements: Section IV.A and Attachment 9 Fast Track Process: Section III.B

New Definitions

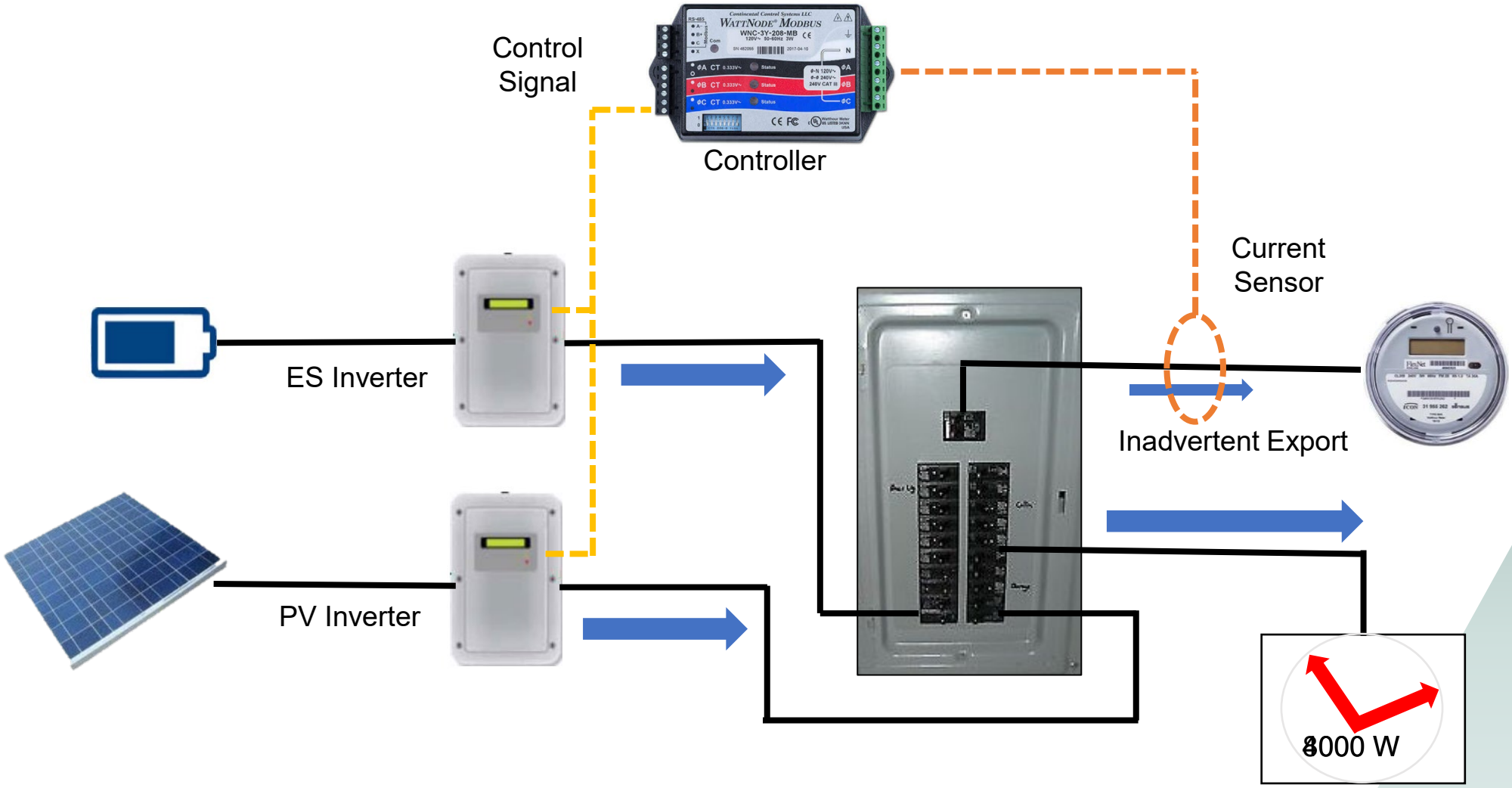
- **Export Capacity** means the amount of power that can be transferred from the DER to the Distribution System. Export Capacity is either the Nameplate Rating, or a lower amount if limited using an acceptable means identified in Section 4.10.
- **Nameplate Rating** means the sum-total of maximum rated power output of all of a DER's constituent generating units and/or ESS as identified on the manufacturer nameplate, regardless of whether it is limited by any approved means.
- **Operating Profile** means the manner in which the distributed energy resource is designed to be operated, based on the generating prime mover, Operating Schedule, and the managed variation in output power or charging behavior. The Operating Profile includes any limitations set on power imported or exported at the Point of Interconnection and the resource characteristics, e.g., solar output profile or ESS operation.
- **Operating Schedule** means the time of year, time of month, and hours of the day designated in the Interconnection Application for the import or export of power.

Solution: Update the Evaluation Process to Account for Export-Controlled Systems

BATRIES Toolkit Recommendations

- Identify 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

Power Control Systems and Inadvertent Export



Initial Review Screens

Opportunities for Improvement

Initial Review Screens

RECOMMENDATIONS

- Use 100% of minimum load in the Minimum Load Screen, and base review on export capacity
- Adopt an Inadvertent Export Screen
- Adopt a Shared Secondary Transformer Screen that evaluates whether aggregated DER export capacity exceeds at least 65% of the transformer nameplate rating

2023 *Model Interconnection Procedures*	Minimum Load Screen: Section III.B.3.a Inadvertent Export Screen: Section III.B.3.b Shared Secondary Screen: Section III.B.3.f

Penetration Screen

- Designed to evaluate generation that could cause reverse power flow
- There is no reverse flow when export is less than minimum load

Impacts	Implementation
• Voltage (steady-state) • Thermal • Operational flexibility • Islanding	• 100% of min load vs. 15% of peak • Daytime minimum load vs. overall minimum • Selection of line section • Export vs. Nameplate • Incorporation of Hosting Capacity Analysis (HCA)

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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	$\frac{(R_{SOURCE} \times \Delta \boldsymbol{P}) - (X_{SOURCE} \times \Delta \boldsymbol{Q})}{V^2}$

Where:

$\Delta \boldsymbol{P}$ = (DER apparent power Nameplate Rating – Export Capacity) × PF,

$\Delta \boldsymbol{Q}$ = (DER apparent power Nameplate Rating – Export Capacity) × $\sqrt{(\mathbf{1} - \boldsymbol{PF^2})}$,

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**

Secondary Transformer Screen

The existing shared secondary transformer screen says

"If the proposed DER is to be interconnected on a single-phase shared secondary, the aggregate generation capacity on the shared secondary, including the proposed generating facility, shall not exceed"

- *Some states and UT use "20 kW"*
- *Some states use "65 % of the transformer nameplate power rating" or "the transformer or secondary conductor rating"*

The existing screen may not reflect voltage regulation (i.e., volt-var settings) activated by the DER. Assuming voltage regulation settings is activated by default settings:

- What is the likelihood of overvoltage occurring?
- Should the screen stay conservative as is?
- Should there be alternate methods for screening with voltage regulation?

This screen evaluates impact from reverse flow, so it should reflect export limits:

- Change "generation capacity" to "export capacity"

Supplemental Review Screens

Opportunities for Improvement

Supplemental Review Screens

RECOMMENDATIONS

Update Supplemental Review process with specified screens, including:

- **A Minimum Load Screen that evaluates whether aggregated DER export capacity is less than 100% of minimum load**
- **A Voltage and Power Quality Screen that evaluates voltage regulation compliance, voltage fluctuation based on limits defined by IEEE 1547, and harmonic levels that meet IEEE 1547 limits at the Reference Point of Applicability**
- **A Safety and Reliability Screen based on export capacity**
- **Bonus: Supplemental Grounding Review**

2023 *Model Interconnection Procedures*	**Minimum Load Screen: Section III.C.3.a** **Voltage and Power Quality Screen: Section III.C.3.b** **Safety and Reliability Screen: Section III.C.3.d** **Supplemental Grounding Screen: III.C.3.c**

Data Sharing and Transparency

Opportunities for Improvement

Data Sharing & Transparency

RECOMMENDATIONS

Require screen results to be provided in a detailed format - size of transformer and how many other homes/businesses are connected to it

Allow customers to request a pre-application report for up to $500

2023 *Model Interconnection Procedures*

Screen Results: Sections III.A.5, III.B.5, and III.C.2
Pre-Application Report: Section II

Detailed Screen Results Example

Example: An Ideal 15% Screen Result

For interconnection of a proposed DER to a radial distribution circuit, the aggregated Export Capacity, including the proposed DER, on the circuit shall not exceed 15% of the line section annual peak load as most recently measured. 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.

Export Capacity of DER Application		kW
Export Capacity of Active DER on Feeder		kW
Export Capacity of DER ahead in Queue		kW
15% of Peak Load		kW
Aggregate Export Capacity, Including Proposed DER		kW
Export Capacity of DER, as % of Load		%
Passes Screen	No	

Example: An Ideal Shared Transformer Screen Result

If the proposed DER is to be interconnected on a single-phase shared secondary, the aggregate Export Capacity on the shared secondary, including the proposed DER, shall not exceed 20 kW or 65% of the transformer Nameplate Rating.

Export Capacity of DER Application		kW
Export Capacity of DER Active on Feeder		kW
Export Capacity of DER Ahead in Queue		kW
Export Capacity of Aggregate DER on Shared Secondary:		kW
Transformer Nameplate Rating:		kW
Export Capacity of Aggregate DER, as a % of Transformer Nameplate Rating:		%
Passes Screen	No	

Pre-Application Report

- Customer requests data for specific Point of Interconnection
- Typically cost ~$300 per report
- Utilities typically respond with data in 10 business days

Upgrade Costs

Opportunities for Improvement

Upgrade Costs

RECOMMENDATIONS

Create a mechanism to enable customers to share the cost of grid upgrades, such as group studies, fixed fees, etc.

2023 *Model Interconnection Procedures*	**Group Study: Section I.D.6**

What is a Group Study?

Serial Studies

- Study projects one at a time
- Projects studied in queue order
- Upgrade costs paid by cost causer

Group Studies

- Study groups of projects together
- Group shares study and upgrade costs

Cost Sharing

- Minnesota has fixed fees for small generators
- New York has a broad cap
- New Mexico has a group study option
  - The updated rules allow the NM Commission “to consider, on a case-by-case basis, whether a particular situation may be eligible for cost-sharing (whether among similarly situated applicants or in rates).”

Cost Sharing Example

- Xcel MN: <40kW, $200 fee

Fund Balance at Quarter-End (December 31, 2023)

Fee	Type	# of Apps	Average $ per App	Total $ Amount
Cost Sharing Fee Deposits	Incoming	2,597	+$200	**+$519,600**
Supplemental Review Fee	Outgoing	343	-$200	**-$68,600**
Upgrade Costs	Outgoing	38	-$8,344	**-$317,082**
	YE NET FUND BALANCE			**+$133,918**

Credit: Xcel Energy

Thank you!

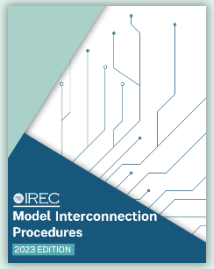
Please reach out if you have any questions

Dave Golembeski
davidg@irecusa.org

Brian Lydic
brian@irecusa.org

To download our resources, go to:

freeingthegrid.org



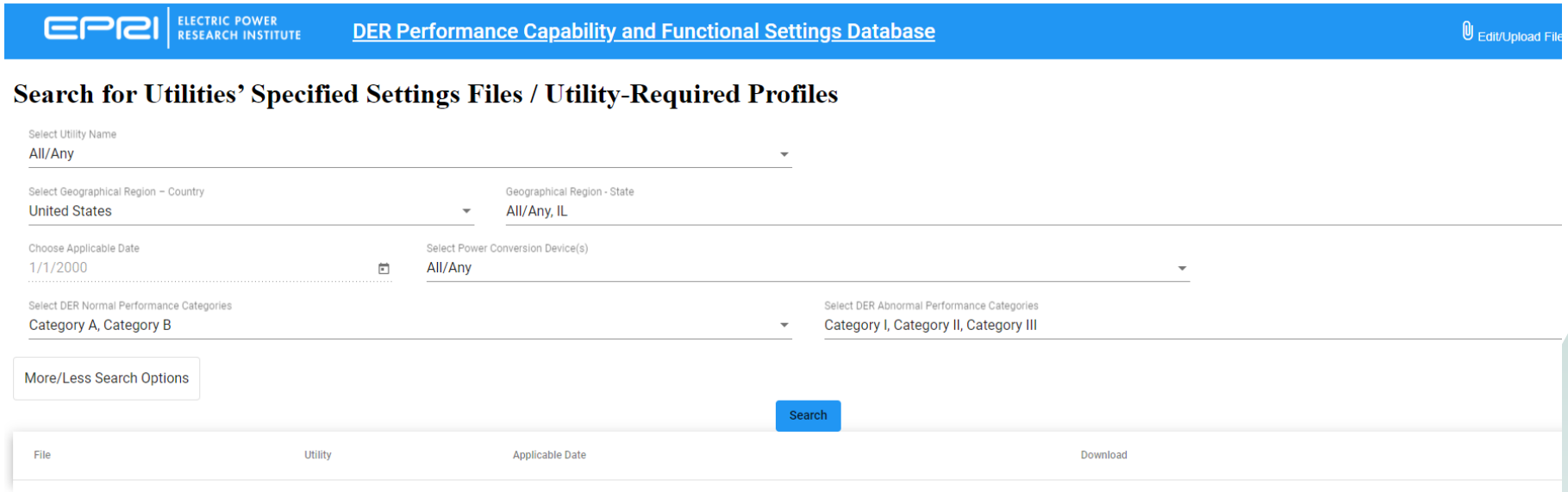
irecusa.org

1547-2018 Adoption Extra Slides

DER Settings – Utility Required Profile (URP)

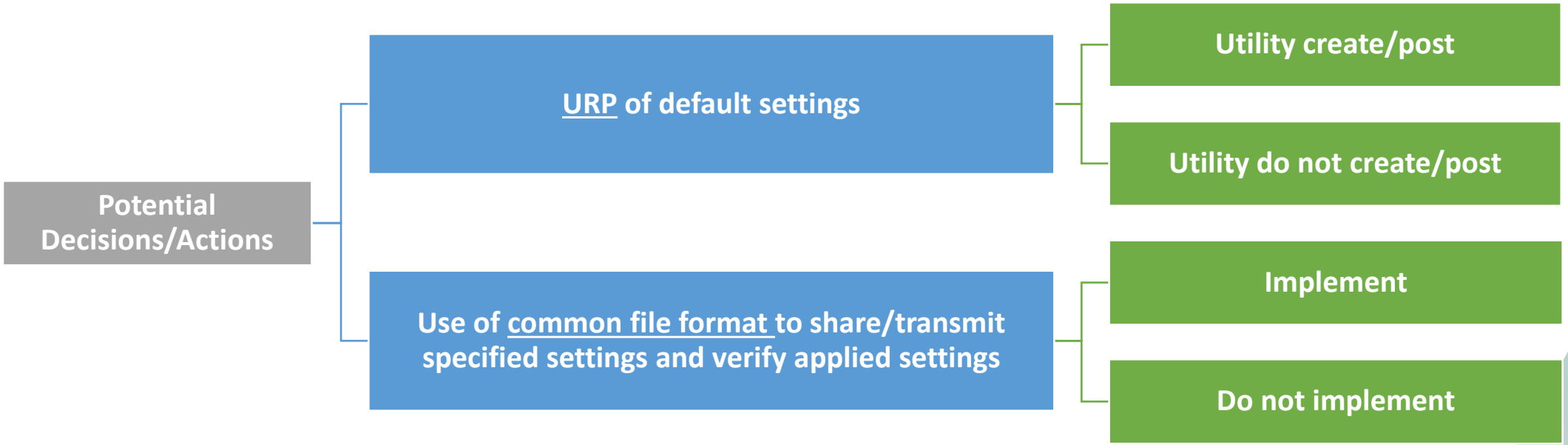
Communicating DER default settings:

- **Finalize URP with all default settings and consider making that publicly available (post in the EPRI URP database)**
- **Implement the use of EPRI's Common File Format for DER settings Exchange and Storage**

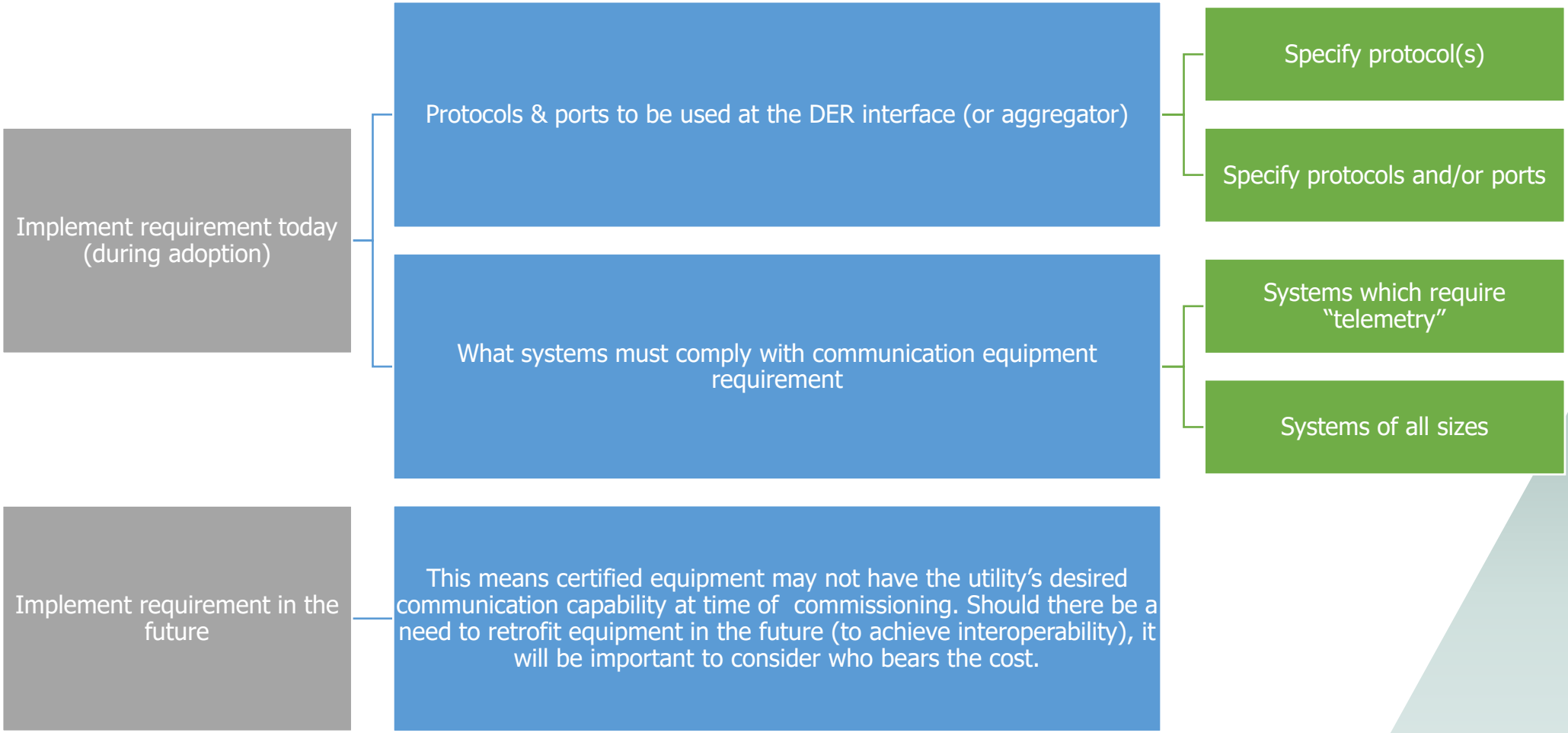


https://dersettings.epri.com/search

DER Settings – Utility Required Profile (URP)



Communications – Protocols, Ports, & Telemetry



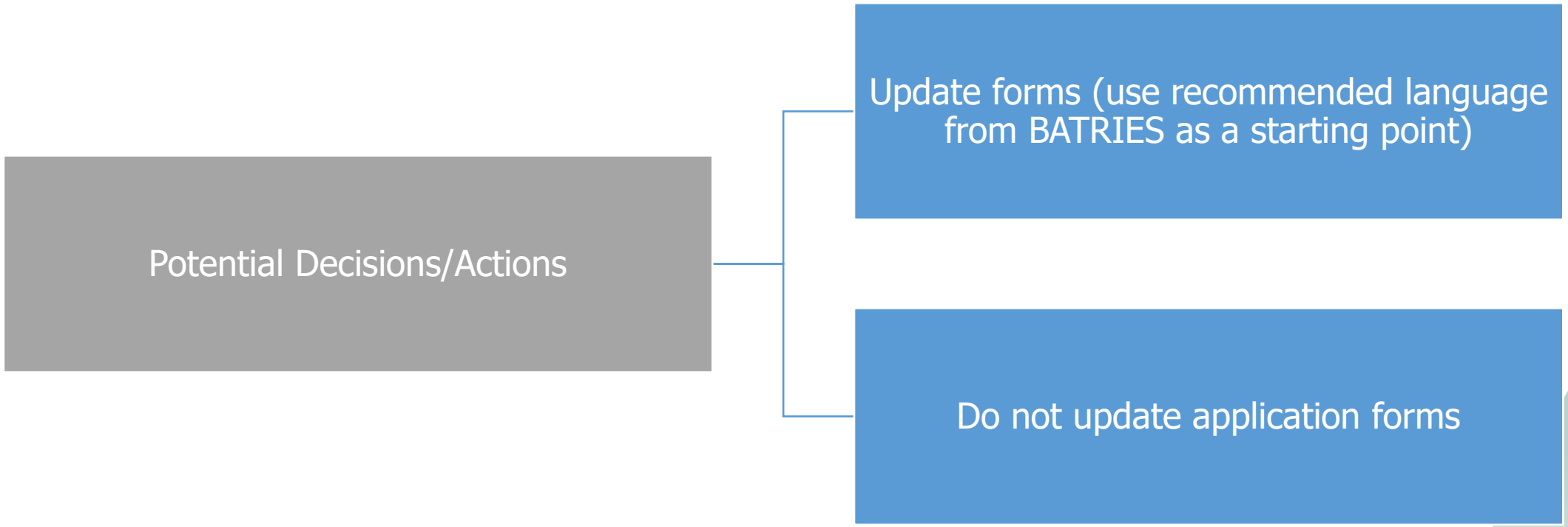
Application Forms

Forms (online portals) offer means to streamline applicant designation and utility review of information. The following items need updating:

- RPA selection
- Enter service randomized delay
- Volt-watt implementation
- Limit active maximum power function implementation
- Frequency droop implementation
- Intentional islanding
- Emergency backup systems
- DER communication capabilities
- Export/import limiting
- Power Control Systems (PCS)
- Inverter fault current

BATRIES addressed some of these, and provides recommended language

Application Forms



See sample recommended language from BATRIES in next slides

Application Forms

VIII. UL 1741 and PCS related: The project team recommends the application forms ask whether or not a PCS is included in the DER system design. Note the blank ___ section is a fill in response from the applicant.

Does the DER include a Power Control System? [yes / no]
(If yes, indicate the Power Control System equipment and connections on the one-line diagram)

What is the PCS maximum open loop response time? _____
What is the PCS average open loop response time? _____

When grid-connected, will the PCS employ any of the following? [Select all that apply]

- ☐ *Unrestricted mode*
- ☐ *Export only mode*
- ☐ *Import only mode*
- ☐ *No exchange mode*
- ☐ *Export limiting from all sources*
- ☐ *Export limiting from ESS*
- ☐ *Import limiting to ESS*

Application Forms

IX. IEEE 1547-2018 related: The project team recommends application forms use the language below to streamline the review of IEEE 1547-2018 capabilities (such as RPA designation, execution of mode of parameter changes, prioritization of DER response).

Where is the desired RPA location? [Check one]

- ☐ *PoC*
- ☐ *PCC*
- ☐ *Another point between PoC and PCC (must be denoted in the one-line diagram)*
- ☐ *Different RPAs for different DER units (must be denoted in the one-line diagram)*

Is the RPA location the same as above for detection of abnormal voltage, faults and open-phase conditions?

- ☐ *Yes*
- ☐ *No (detection location must be denoted in the one-line diagram)*

Why does this DER fit the chosen RPA? [Check all that apply]

- ☐ *Zero-sequence continuity between PCC and PoC is maintained*
- ☐ *The DER aggregate Nameplate Rating is less than 500 kVA*
- ☐ *Annual average load demand is greater than 10% of the aggregate DER Nameplate Rating, and it is not capable of, or is prevented from, exporting more than 500 kVA for longer than 30 seconds.*

Application Forms

Does the DER utilize export limiting for the Limit Maximum Active Power function (Yes/No)
Which equipment(s) achieves this functionality?
Is the equipment certified for export limiting (PCS, or "plant controller" via 1547.1 test 5.13)?

In addition to grid-connected mode, will the DER operate as an intentional local EPS island (also known as "microgrid" or "standby mode")?

When grid-connected, does the DER employ any of the following? [Select all that apply]

- ☐ *Scheduled Operation*
- ☐ *Export limiting or control*
  - ☐ *Does the export limiting method limit on the basis of kVA or kW?*
- ☐ *Import limiting or control*
  - ☐ *Does the import limiting method limit on the basis of kVA or kW?*
- ☐ *Active or reactive power functions not specified in IEEE 1547 (such as the Set Active Power function)*

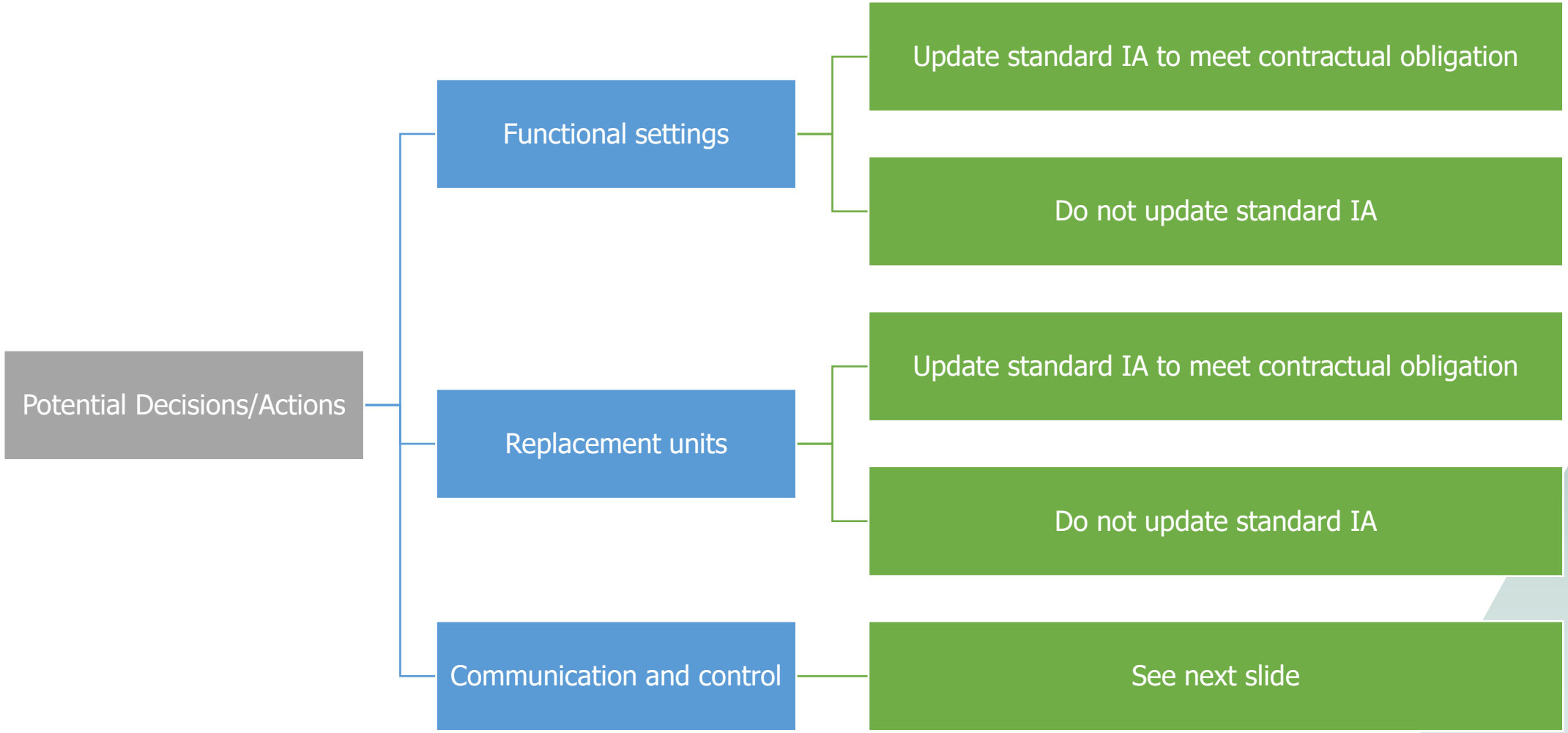
Application Forms

Is the DER, or part of the DER, designated as emergency, legally required, or critical facility backup power? [yes / no]
(If yes, denote the emergency generators and applicable portions of the DER in the submitted one-line diagram)

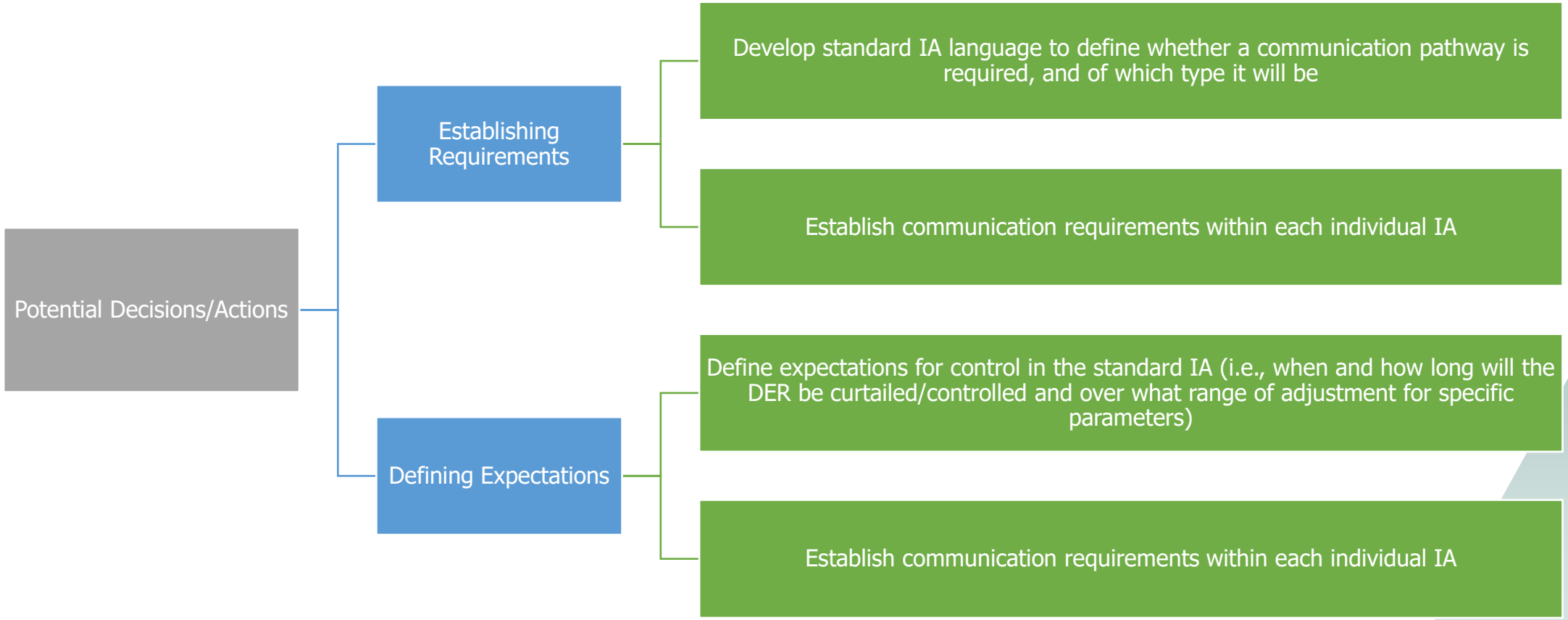
How is the voltage-active power function implemented? [Check one]

- ☐ *All DER units follow the same functional settings (same per-unit curve regardless of individual unit Nameplate Rating)*
- ☐ *Different DER units follow different functional settings (different per-unit curves for individual unit Nameplate Ratings)*
  - ☐ *Denote in one-line diagram the voltage-active power settings of each DER unit*
- ☐ *A plant controller or other supplemental DER device manages output of the entire system (one per-unit curve based on total system Nameplate Rating)*
  - ☐ *If selected, is the managing device certified for the voltage-active power function? [yes / no]*
- ☐ *Export limit is utilized (power control system manages export based on total system Nameplate Rating)*
  - ☐ *If selected, is the managing device certified for the voltage-active power function? [yes / no]*

Interconnection Agreements (IA)

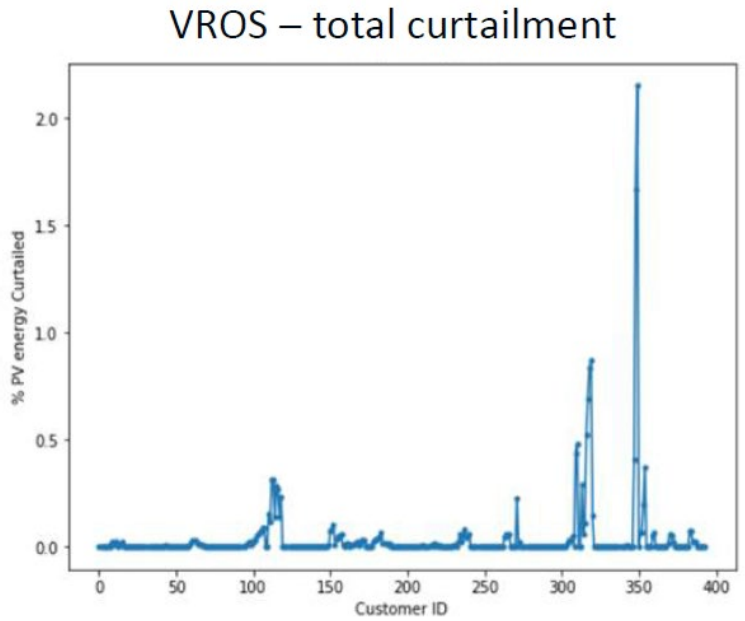


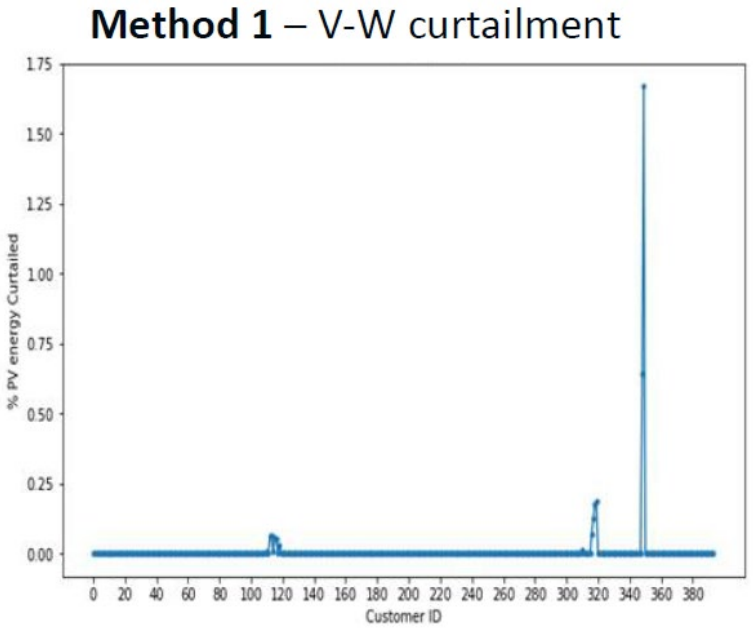
Interconnection Agreements (IA) – Communications



Volt-Watt Curtailment

- Ensure complaint process handles DER complaints appropriately
- Consider reporting on how many voltage-based curtailment issues arise
- Consider metric based on voltage data to determine potential for curtailment





Credit: NREL

Volt-Watt Curtailment Reports

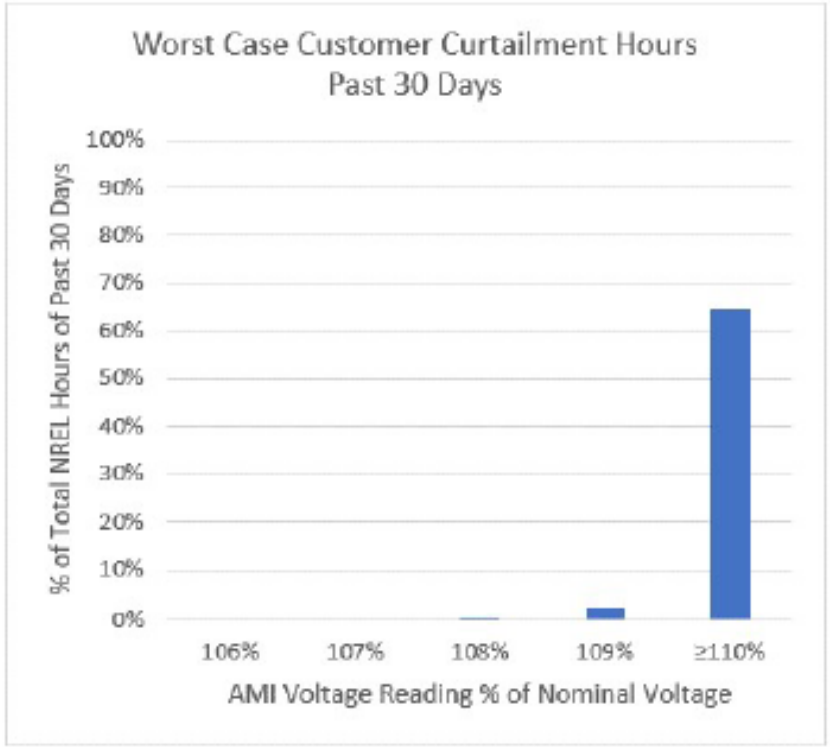
California Experience

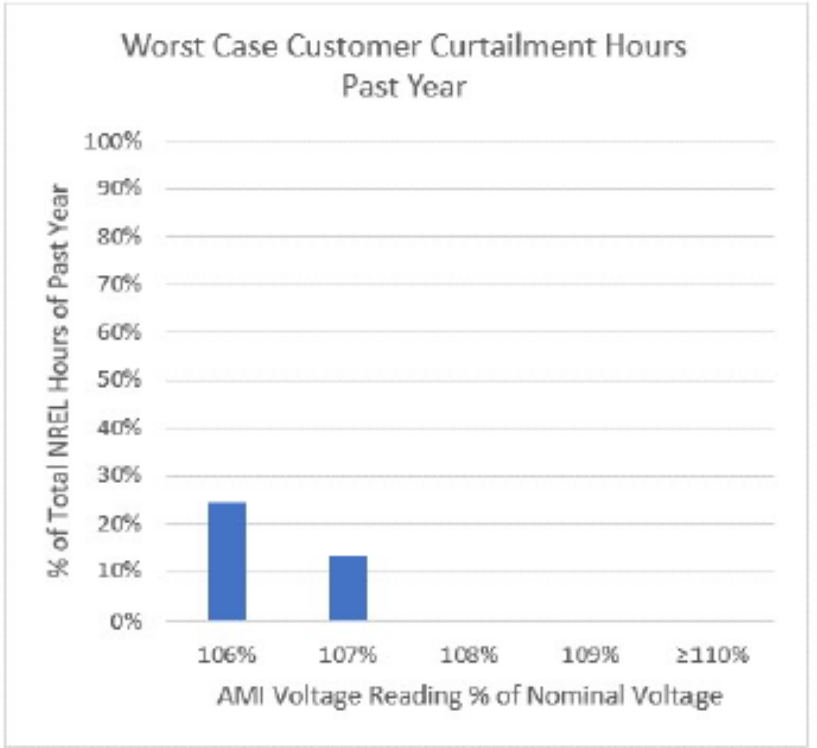
- California IOUs have been reporting on the power quality complaint process since February 2021
- For PV customers with volt-watt curtailment complaints, AMI data is used to note volt-watt triggering events
- Output potential is assumed to be 100% between 9am - 3pm
- Overview as well as amounts/corrective action categories per issue are included; worst-case customer voltages

Summary Results for Utility (or Pending) Mitigations		
NREL Method 1 Estimation of Curtailment %	# of Customers with 1 year Curtailment %	# of Customers with 1 month Curtailment %
≤ 2%	15	10
> 2% ≤ 4%	0	1
>4%	4	8
Total	19	19

Summary Results for Customer Issues		
NREL Method 1 Estimation of Curtailment %	# of Customers with 1 year Curtailment %	# of Customers with 1 month Curtailment %
≤ 2%	16	15
> 2% ≤ 4%	2	0
>4%	0	3
Total	18	18

Worst Case Customer (>5% Curtailment) Voltage Histograms





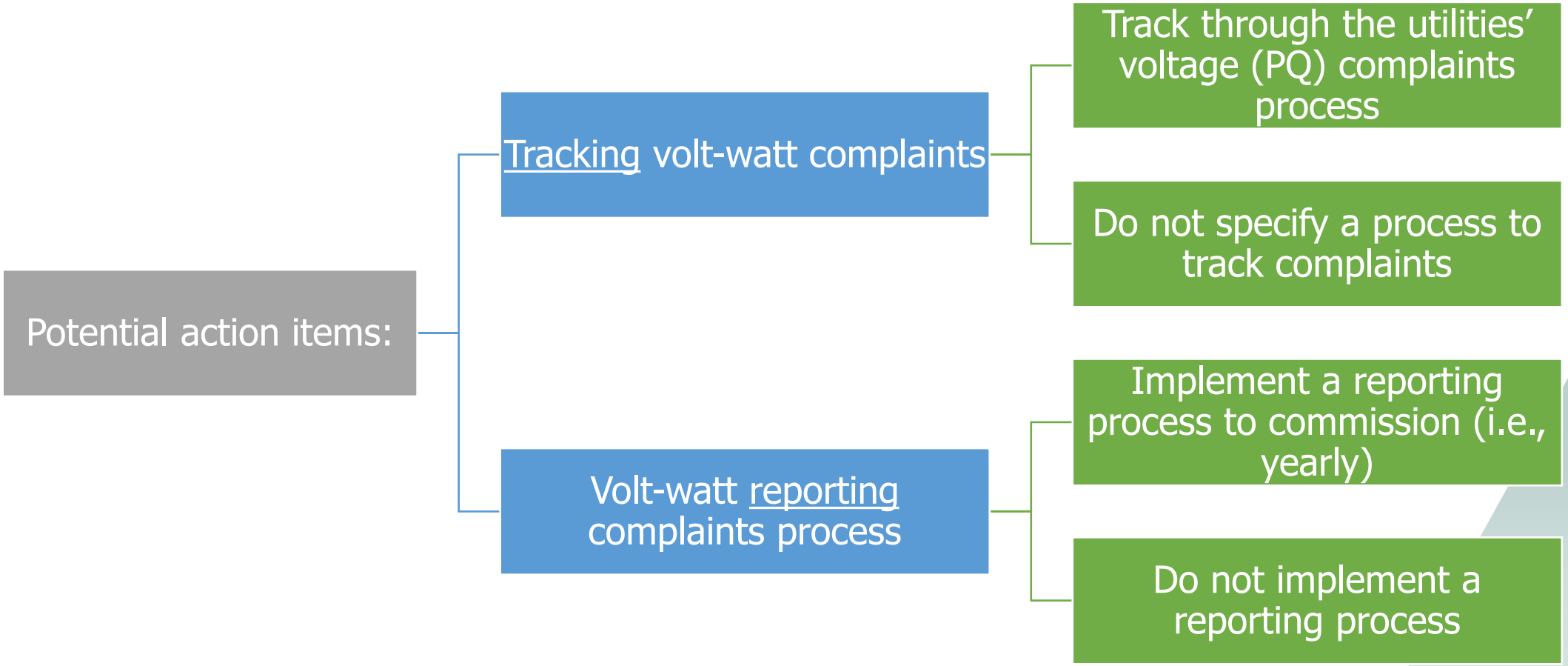
Per Customer Curtailment Calculations and Mitigations			
Customer ID	1 Year Curtailment %	1 Month Curtailment %	Mitigation
1	0.2%	0.0%	CUSTOMER ISSUE
2	3.8%	0.0%	CUSTOMER ISSUE
3	1.2%	7.4%	CUSTOMER ISSUE
4	0.0%	0.3%	CUSTOMER ISSUE
5	0.1%	0.1%	CUSTOMER ISSUE
6	0.8%	5.2%	CUSTOMER ISSUE
7	0.0%	0.1%	CUSTOMER ISSUE
8	0.8%	0.0%	CUSTOMER ISSUE
9	0.0%	0.1%	CUSTOMER ISSUE
10	0.0%	0.3%	CUSTOMER ISSUE
11	0.2%	0.0%	CUSTOMER ISSUE
12	0.4%	0.1%	CUSTOMER ISSUE
13	0.2%	0.0%	CUSTOMER ISSUE
14	0.1%	0.2%	CUSTOMER ISSUE
15	0.2%	0.4%	CUSTOMER ISSUE
16	2.1%	11.6%	CUSTOMER ISSUE
17	0.1%	0.0%	CUSTOMER ISSUE
18	0.0%	0.1%	CUSTOMER ISSUE
19	0.3%	1.0%	DIST - CHANGE SETTINGS
20	0.1%	0.0%	DIST - REPAIR EQUIPMENT
21	1.4%	8.6%	DIST - REPAIR EQUIPMENT
22	0.1%	1.4%	DIST - REPAIR EQUIPMENT
23	0.3%	0.0%	DIST - REPAIR EQUIPMENT
24	0.2%	0.0%	DIST - TREE TRIMMING
25	1.8%	2.2%	PENDING
26	0.1%	1.1%	PENDING
27	7.3%	21.3%	PENDING
28	0.4%	4.3%	SEC/SVC - REPAIR
29	1.6%	8.4%	SEC/SVC - REPAIR
30	0.1%	0.2%	SEC/SVC - REPAIR
31	0.2%	0.0%	SEC/SVC - REPAIR
32	5.8%	16.2%	SEC/SVC - REPLACE
33	0.1%	0.0%	SEC/SVC - REPLACE
34	0.4%	0.0%	SEC/SVC - REPLACE
35	0.4%	4.6%	SUB/TRANS - CHANGE SETTINGS
36	4.5%	22.1%	TX - REPLACE
37	5.8%	67.2%	TX - REPLACE

Volt-Watt Curtailment Reports

California Experience

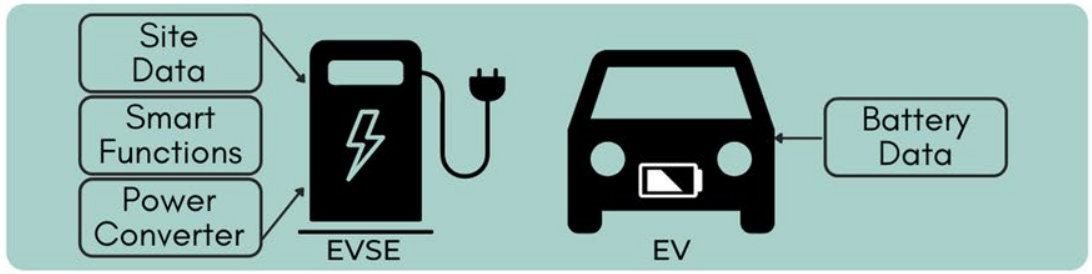
- PG&E (largest IOU) reported only 9 customers with potential yearly curtailment >4%
- Worst yearly potential loss reported was 38.7% (failing distribution transformer)
- Next highest was 7.3%
- It appears true that volt-watt is unlikely to cause widespread curtailment, but individual customers can be highly impacted

Volt-Watt Curtailment



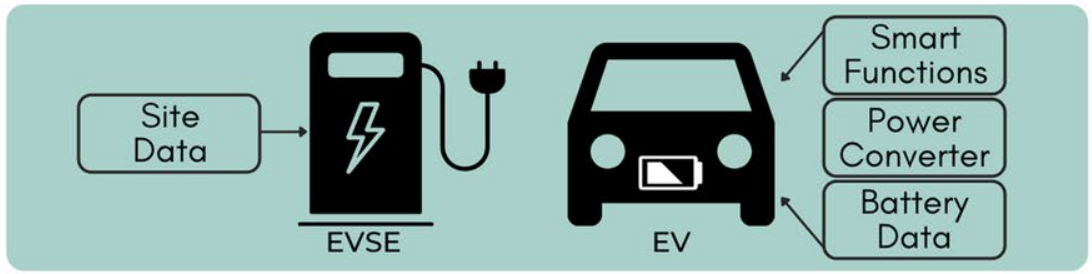
Related V2G Interconnection Standards

V2G-DC



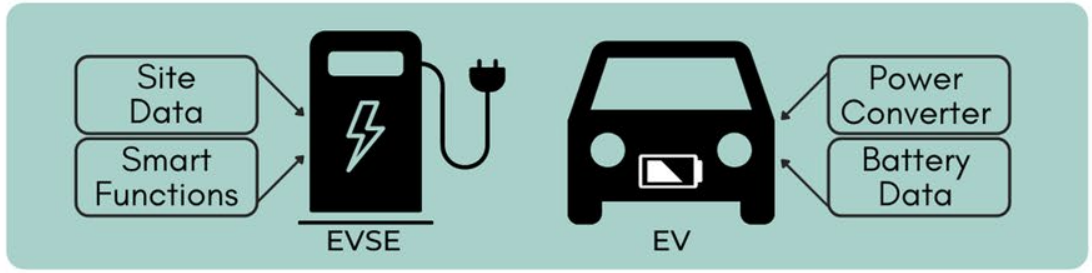
Expected Conformance:
EVSE is listed to UL 1741 (could include SA or SB).

V2G-AC



Expected Conformance:
EVSE is listed to UL 1741 SC.
EV is certified to SAE J3072.

V2G-SPLIT INVERTER



Expected Conformance:
Not clear yet, however, in practice, the EVSE and EV will need to be tested to IEEE 1547.1.

UL 1741 SA/SB are published. UL 1741 SC is forthcoming

https://irecusa.org/resources/paving-the-way-vehicle-to-grid-standards-for-electric-vehicles/

Export Capacity Extra Slides

What Are the Benefits of Storage Flexibility?

KEY BENEFITS

- Reduces interconnection costs
- Optimizes the use of DERs
- Provides cost & energy management benefits
- Increases grid reliability and resilience

Interconnection Rules Govern Storage Discharge, Other Rules Govern Charging

- The existing regulatory framework was not designed for storage in mind: interconnection rules focus on power flowing out, not in
- Rules for new or additional load are quite different in the level of detail on technical review and the way costs may be allocated
- BATRIES covers some aspects of controlling import but does not detail the technical review for charging because of the existing bifurcation

Possible Ways to Resolve Charge/Discharge Rule Bifurcation

- Ensure technical review happens concurrently
- Clarify how cost allocation rules will be applied where upgrades are needed for both charging and discharging
- Or, consider merging the rules and review for storage
- Other considerations:
  - Using controls to ensure net energy metering credits are not given for grid-charged (“brown”) power

Non-Export Storage

DER that is sized, designed, and operated using any of the [acceptable export control methods approved by the PUC], such that the output is used for Host Load only and no electrical energy (except for any Inadvertent Export) is transferred from the DER to the Distribution System

Non-Export Storage Basics

- The electric output of the storage system is used for the load it is designed to serve, not for grid export
- Characteristics:
  - Use advanced controls to prevent exporting power to the grid
  - Can be charged using on-site generation (e.g., solar) or directly from the grid
- A handful of states have recognized this capability

Non-Export Storage Basics

- Customers may want to design their storage systems as non-exporting to:
  - Pair solar with storage and serving only their on-site load (e.g., single- or multi-family residence; small business; hospital or university campus)
  - Avoid or reduce grid impacts and the need for costly infrastructure upgrades
  - Where rate structures do not exist to compensate adequately (or at all) for exported power

Non-Export: Not New But Also Not Common

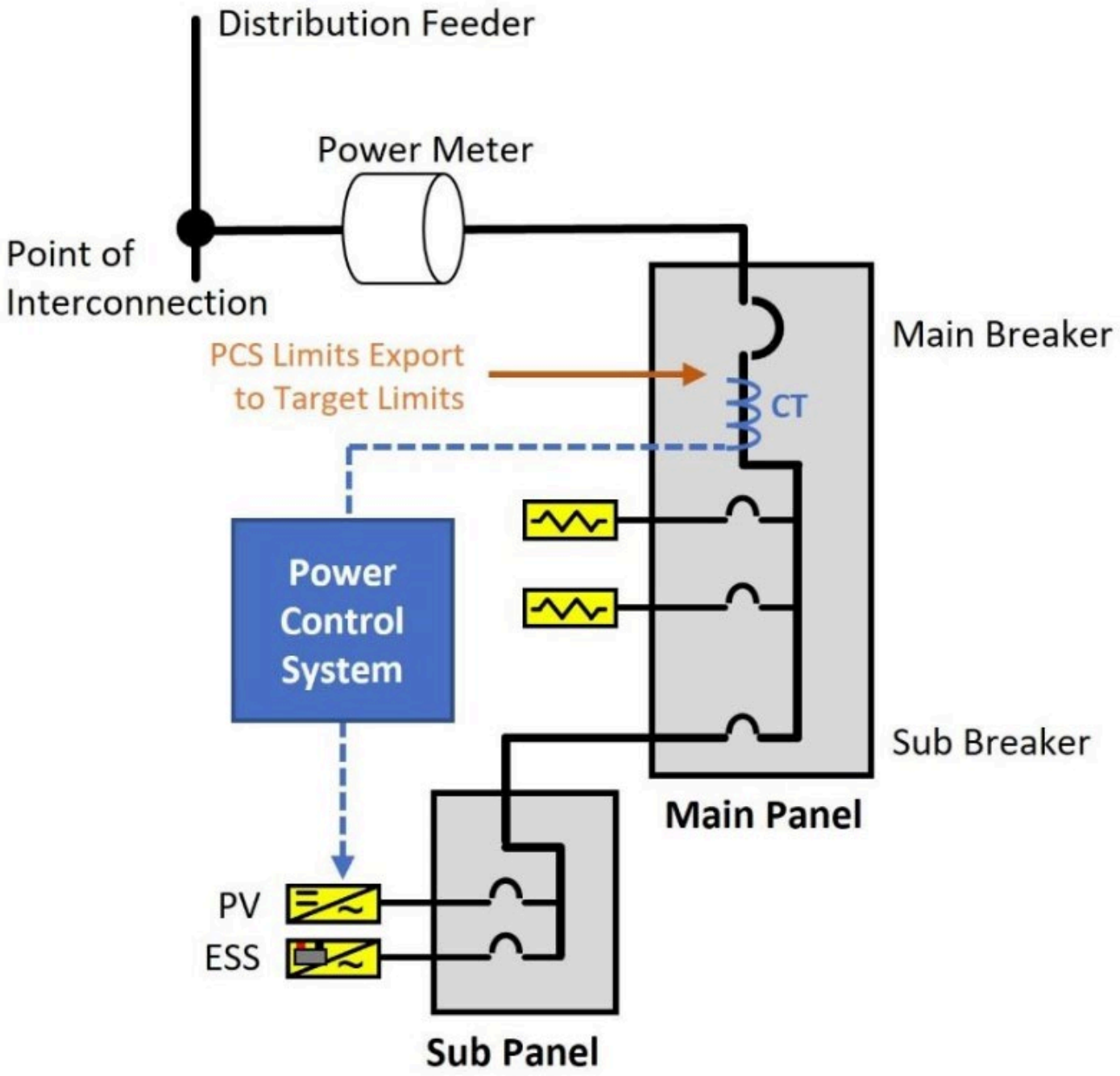
- Some interconnection rules do not recognize the concept of non-export or provide any detail on how to review
- Some rules provide a separate review path for non-export projects or recognize that traditional screens should be applied differently for projects that do not export
- Some detail on the type of export controls that can be used (though may not be current on available control technologies)

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

Power Control System



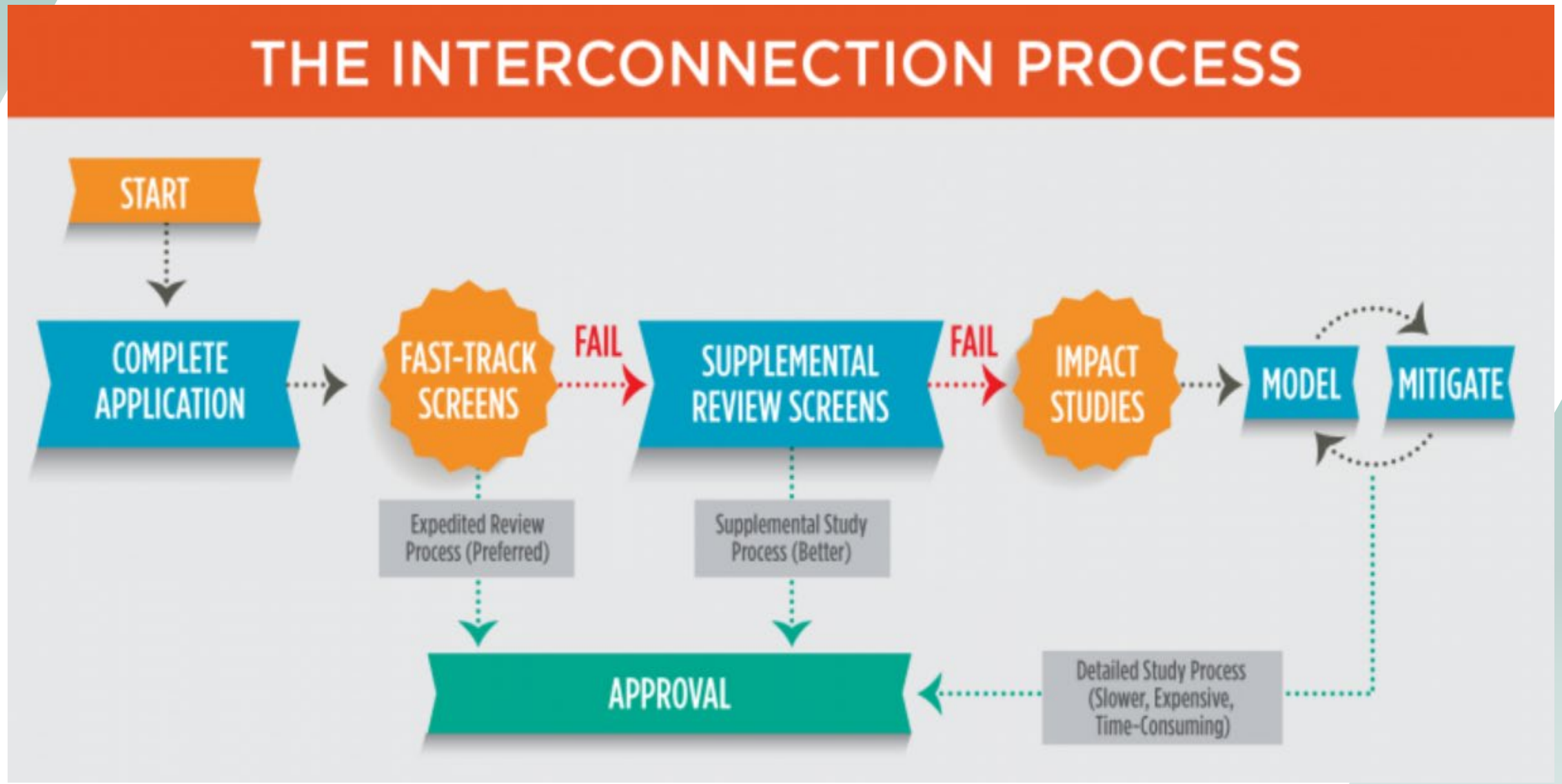
Screen Categories

- Screens in Which Export Capacity is Appropriate to Use When Assessing Impacts
- Screens Where Evaluation is Not Impacted by Export Controls
- Other Screen Recommendations

Screens Recommendations for FERC SGIP

Screen	Change	Nameplate	Export
2.1.1.1 Available service	none	n/a	n/a
2.1.1.2 ≤15% of peak rule	Use DER export		X
New Screen: Inadvertent export	**add ΔV <3%***	**X**	**X**
2.1.1.3 if network (spot/area)	Use DER nameplate	X	
2.1.1.4 ≤10% increase in fault current	Use DER nameplate	X	
2.1.1.5 <87.5% interrupting capability	Use DER nameplate	X	
2.1.1.6 Grounding compatibility	Consider inverter DER	n/a	n/a
2.1.1.7 Shared secondary <65% of trans. or <20kW	Use DER export		X
2.1.1.8 120/240 Unbalance <20% of trans. kVA	Use DER nameplate	X	
2.1.1.9 Shall not exceed 10 MW	Use DER nameplate	X	
2.4.4.1 Minimum load screen <100%	Use DER export		X
2.4.4.2 Voltage and PQ screen	Consider export control	X	X
2.4.4.3 Safety and reliability screen	Consider export control	X	X

*Use nameplate rating - export to determine if ΔV <3% as a RVC



Solar Energy Technologies Office, May 2016

Screens Where Evaluation Is Not Impacted by Export Controls

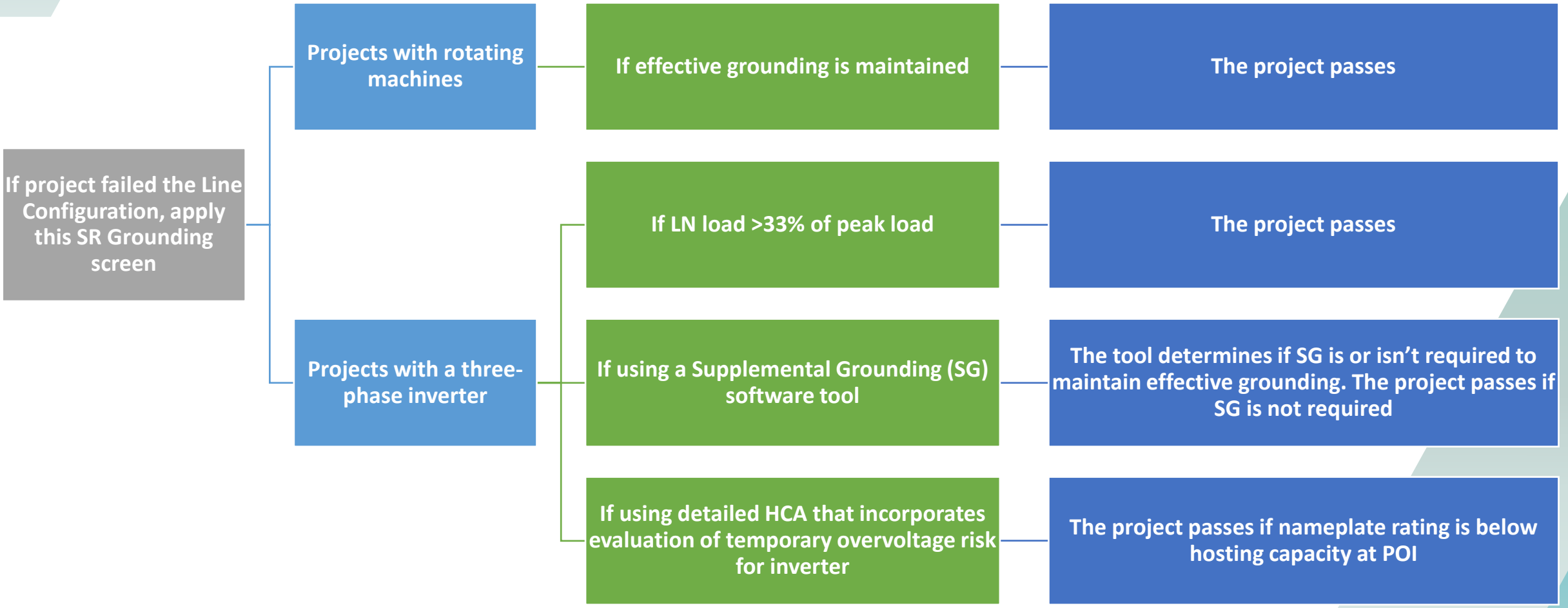
- There are several screens where evaluation of the full nameplate rating is crucial for the technical assessment
  - Spot network screen
  - Service imbalance screen
  - Transient stability screen
- The protection screens (87.5% of interrupt and 10% increase in fault current) should evaluate a project's actual fault current
  - Fault current screen
  - Short circuit contribution screen

Screens Extra Slides

Line Configuration Screen (LCS)

- The existing LCS may not recognize the difference between inverters vs. rotating machines.
- Follow IEEE C62.92.6 guidelines and screen inverters and rotating machines distinctly.
- Consider using screen based on line type only (e.g. IL 466)

Grounding Review Within Supplemental Review (SR)



Material Modification Extra Slides

Opportunities for Improvement

Modifications

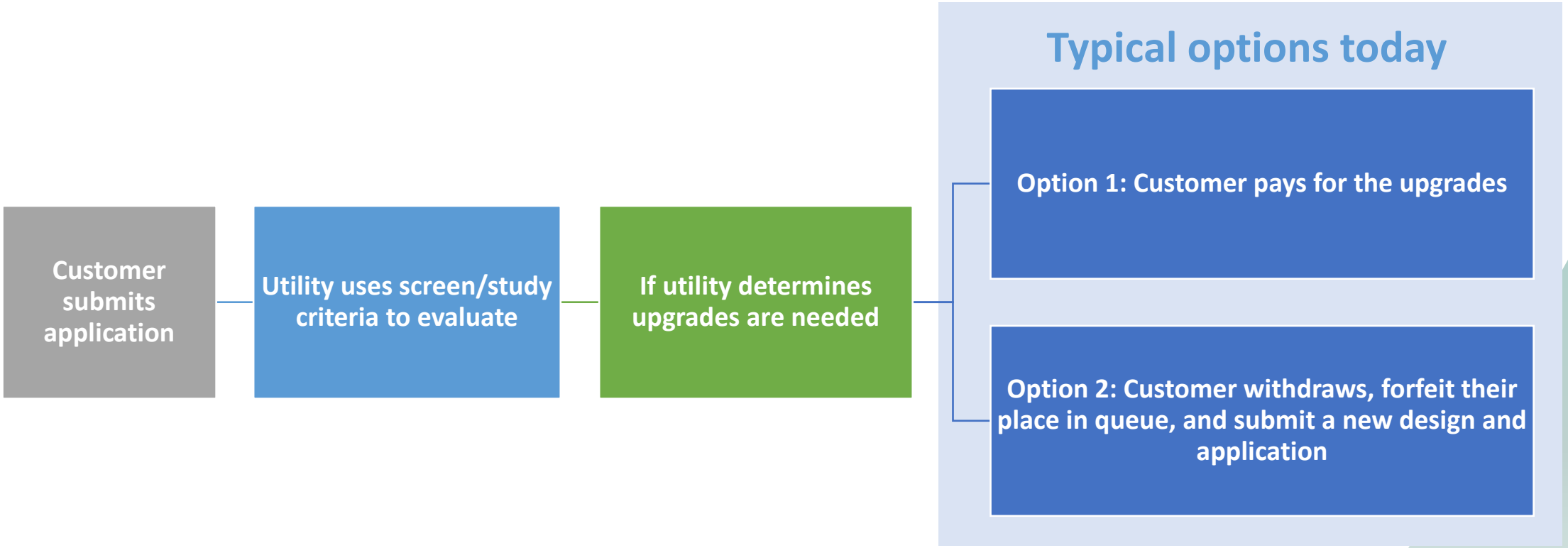
RECOMMENDATIONS

Define material modification and the process associated with requesting material modification review

2023 *Model Interconnection Procedures*

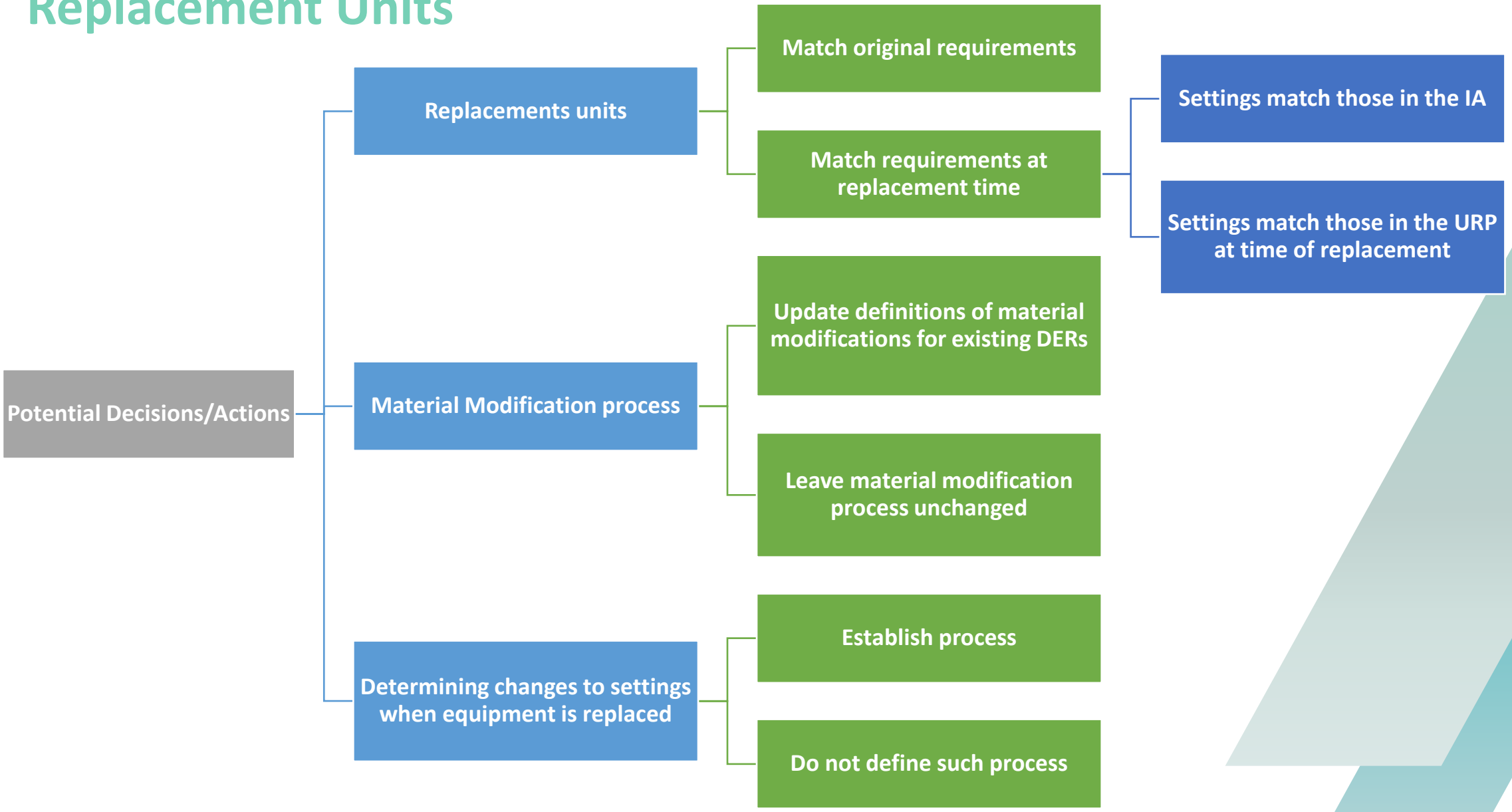
Minor Project Modifications After Screening: Section III.D
Modification Process: Section I.D.4
(both Minor and Material Modifications)

Current Process for Changing System Design During Interconnection Review



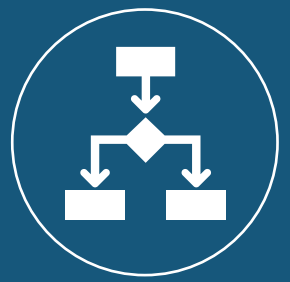
Most states rules don't include provisions for system design changes i.e., There is no place to allow for potential design changes to address screen results failure (We need Option 3)

Replacement Units



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

Replacement Units

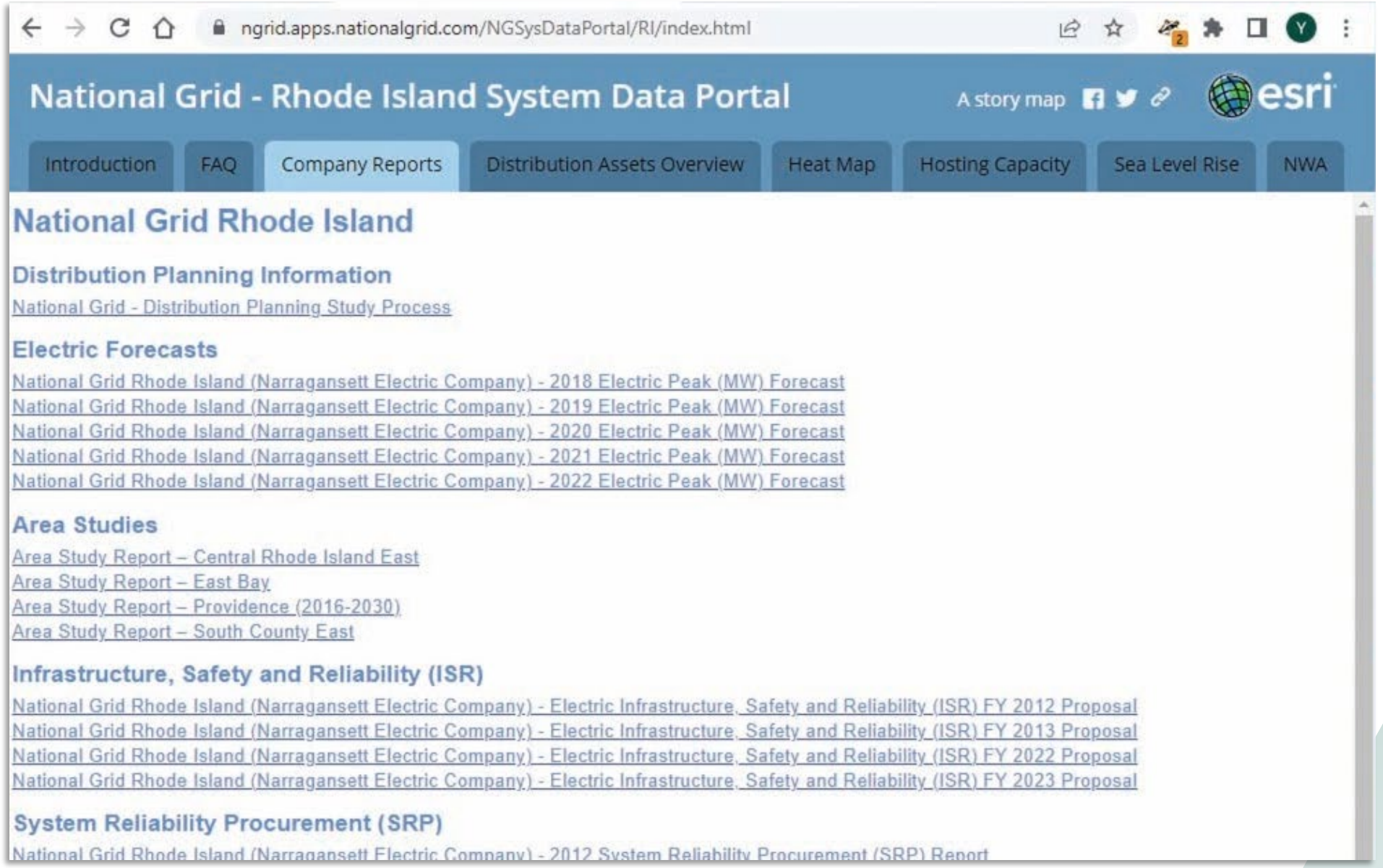
For end-of-life, define whether the most recent technical requirements, certifications and settings must be followed. However, make exceptions on like-for-like:

- If through warranty replacement, or
- If customer has spare parts on hand for future use

Data Sharing and Transparency Extra Slides

Distribution System Data Portals

- Website with downloadable data sets and reports about distribution grid conditions and constraints
- Typically includes:
  - load profiles
  - distribution system asset information
  - interconnection queues
  - distribution system planning assumptions & studies
  - substation and feeder data


ngrid.apps.nationalgrid.com/NGSysDataPortal/RI/index.html
National Grid - Rhode Island System Data Portal
A story map
esri
Introduction
FAQ
Company Reports
Distribution Assets Overview
Heat Map
Hosting Capacity
Sea Level Rise
NWA
National Grid Rhode Island
Distribution Planning Information
National Grid - Distribution Planning Study Process
Electric Forecasts
National Grid Rhode Island (Narragansett Electric Company) - 2018 Electric Peak (MW) Forecast
National Grid Rhode Island (Narragansett Electric Company) - 2019 Electric Peak (MW) Forecast
National Grid Rhode Island (Narragansett Electric Company) - 2020 Electric Peak (MW) Forecast
National Grid Rhode Island (Narragansett Electric Company) - 2021 Electric Peak (MW) Forecast
National Grid Rhode Island (Narragansett Electric Company) - 2022 Electric Peak (MW) Forecast
Area Studies
Area Study Report – Central Rhode Island East
Area Study Report – East Bay
Area Study Report – Providence (2016-2030)
Area Study Report – South County East
Infrastructure, Safety and Reliability (ISR)
National Grid Rhode Island (Narragansett Electric Company) - Electric Infrastructure, Safety and Reliability (ISR) FY 2012 Proposal
National Grid Rhode Island (Narragansett Electric Company) - Electric Infrastructure, Safety and Reliability (ISR) FY 2013 Proposal
National Grid Rhode Island (Narragansett Electric Company) - Electric Infrastructure, Safety and Reliability (ISR) FY 2022 Proposal
National Grid Rhode Island (Narragansett Electric Company) - Electric Infrastructure, Safety and Reliability (ISR) FY 2023 Proposal
System Reliability Procurement (SRP)
National Grid Rhode Island (Narragansett Electric Company) - 2012 System Reliability Procurement (SRP) Report

Requested Substation & Feeder Data - Summary

- Name or identification number
- Transformer rating & bus-ties present
- Number of phases
- Feeder type & length, conductor size
- Aggregate existing, queued, and total export capacity
- Is it an area, spot, or radial network?
- Voltages
- Load profile (8760 hours)
- Percentage of each customer type
- Scheduled upgrades
- Upgrades for reverse power flow? (yes/no)
- Federal or state jurisdiction
- Existing or known constraint requires study
- Any other information relevant to the applicant

Dispute Resolution
Extra Slides

Comparing UT's Rules to Best Practices

Opportunities for Improvement

Dispute Resolution	UT	Points Possible
	1	3

RECOMMENDATIONS

Require the Commission or other entity to offer services of a mediator or ombudsperson to track and facilitate dispute resolution +1

Adopt a regular interconnection forum to resolve ongoing technical and policy issues +1

2023 *Model Interconnection Procedures*	Dispute Resolution Process: Section IV.E Ombudsperson: Section IV.C.2 and Section IV.E.2-5 Interconnection Forum: Section IV.G