Energy Storage Interconnection Best Practices

January 17, 2025

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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.

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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.

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

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.

Default Assumption

The full nameplate capacity of a system will export at 100%, 100% of the time.

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)

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]

Limited-Export Storage Basics

- Characteristics:
  - Use controls to set a maximum export power amount that is lower than the full nameplate capacity of the ESS
  - Can also be charged using on-site generation or the grid
- Critical example: a limited export system may be one where co-located solar + storage are not designed to export simultaneously

Limited-Export Storage Basics

- Customers may want to design their storage systems to limit export to:
  - Avoid or reduce grid impacts and the need for costly infrastructure upgrades
  - To take advantage of time of use or other rate structures with differentiated pricing
  - To maximize on-site energy use

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 schedule or dynamic

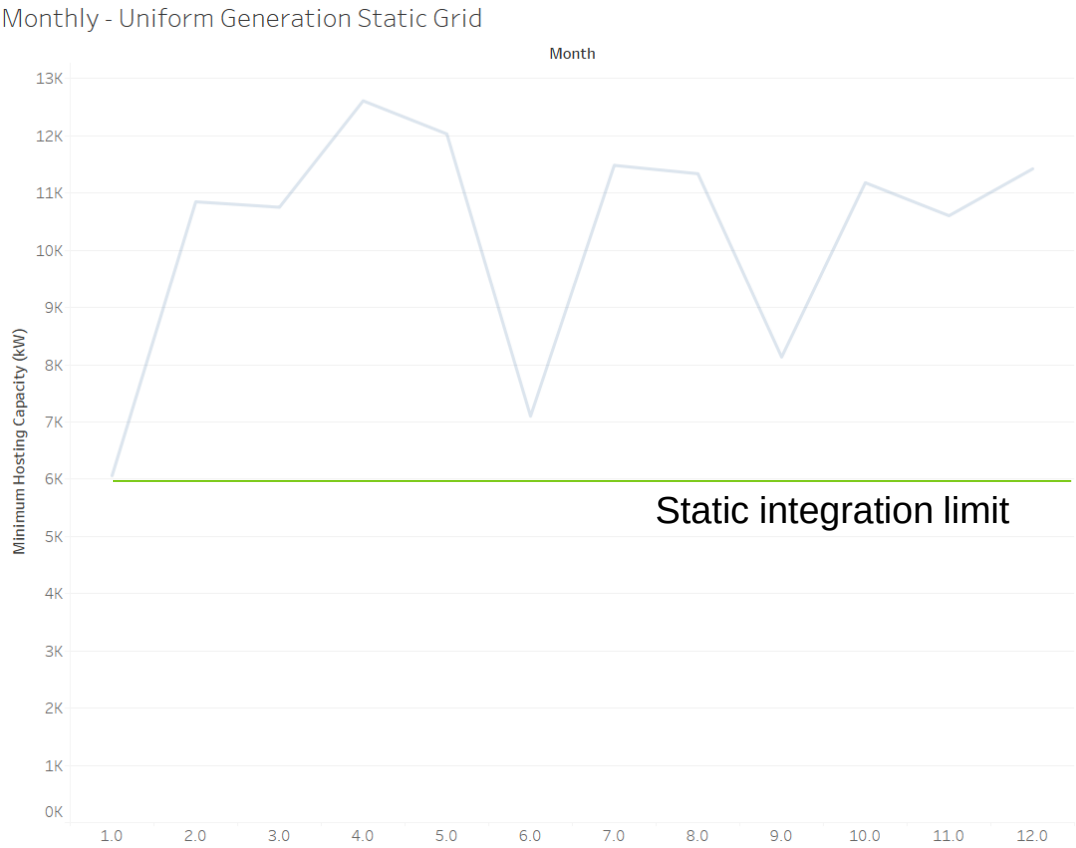
How To Enable Export-Controlled Storage Systems

Identify Acceptable Export Control Methods

Update Screening/Study Processes to Account for Controls

Allow for System Design Changes During Review

Hosting Capacity



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

- Freestanding section in rules should identify the six acceptable means
- Identify technical requirements for each type (try not to duplicate or contradict certifications)
- Be explicit that if an applicant uses one of the acceptable means there does not need to be additional customized review and that the export capacity specified should be used in the review process
- Provide an option for applicants to propose other means but allow the utility to review and approve

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

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

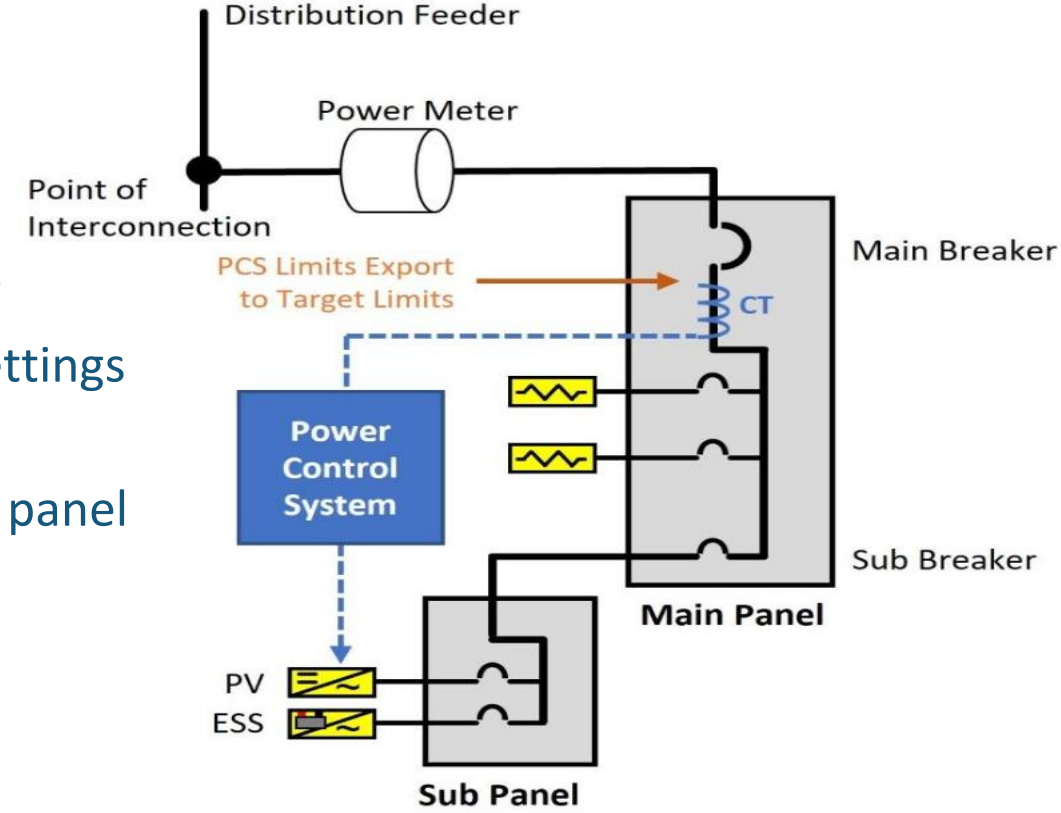
IEEE Std 1547-2018 Nameplate Rating Parameter Name	IEEE Std 1547-2018 Nameplate Rating Parameter Label	Configuration Setting Parameter Name	Configuration Setting Parameter Label
Active power rating at unity power factor	NP_P_MAX	Active power rating at unity power factor applied setting	NP_P_MAX-AS
Active 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.”

Certified Power Control Systems (PCS)

- UL 3141
  - Fail-safety
  - Max 30s response
  - Protected from settings changes
  - Also used for NEC panel overload



Agreed Upon Means

- In addition to using one of the “accepted” methods, BATRIES recommends including a provision to allow other export control methods *with utility approval*
- Over time additional methods that become available (particularly through further certifications) could be added to the list of “acceptable” methods

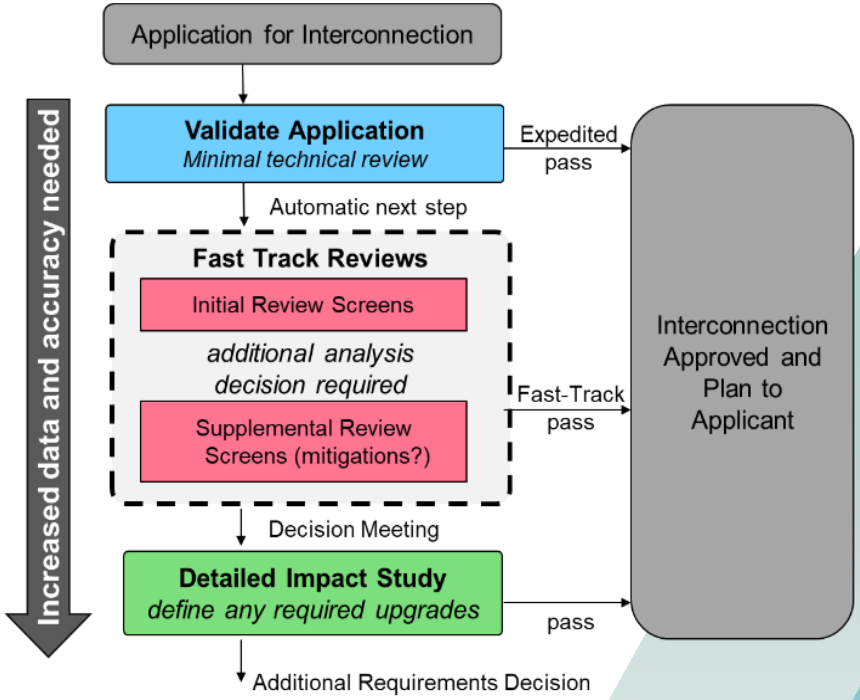
Types of Controls

Acceptable Export Control Methods		
	For Non-Exporting DER	For Limited-Export DER
a) Reverse Power Protection (Device 32R*)	Yes	
b) Minimum Power Protection (Device 32F*)	Yes	
c) Relative Distributed Energy Resource Rating	Yes	
d) Directional Power Protection (Device 32*)		Yes
e) Configured Power Rating		Yes
f) Limited Export Utilizing Certified PCS	Yes	Yes
g) Limited Export Using Agreed-Upon Means	Yes	Yes

* ANSI[36] device numbers are listed in parentheses, as defined by IEEE C37.2 IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.

Current Evaluation Process for DER Systems

- Tiered review approach with both a screening and study process
- Screens and supplemental review support fast track
- These need to consider export control methods in the future
- Failing fast track will often require studies which also need to consider approved export limiting methods



Overview of the FERC SGIP Screens

KEY – Recommended Action from Toolkit

Does not require revision

Requires revision, should use Export Capacity

May still use Nameplate

Addressed in previous workshop

Most States use FERC SGIP format for Fast Track Screens

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

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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

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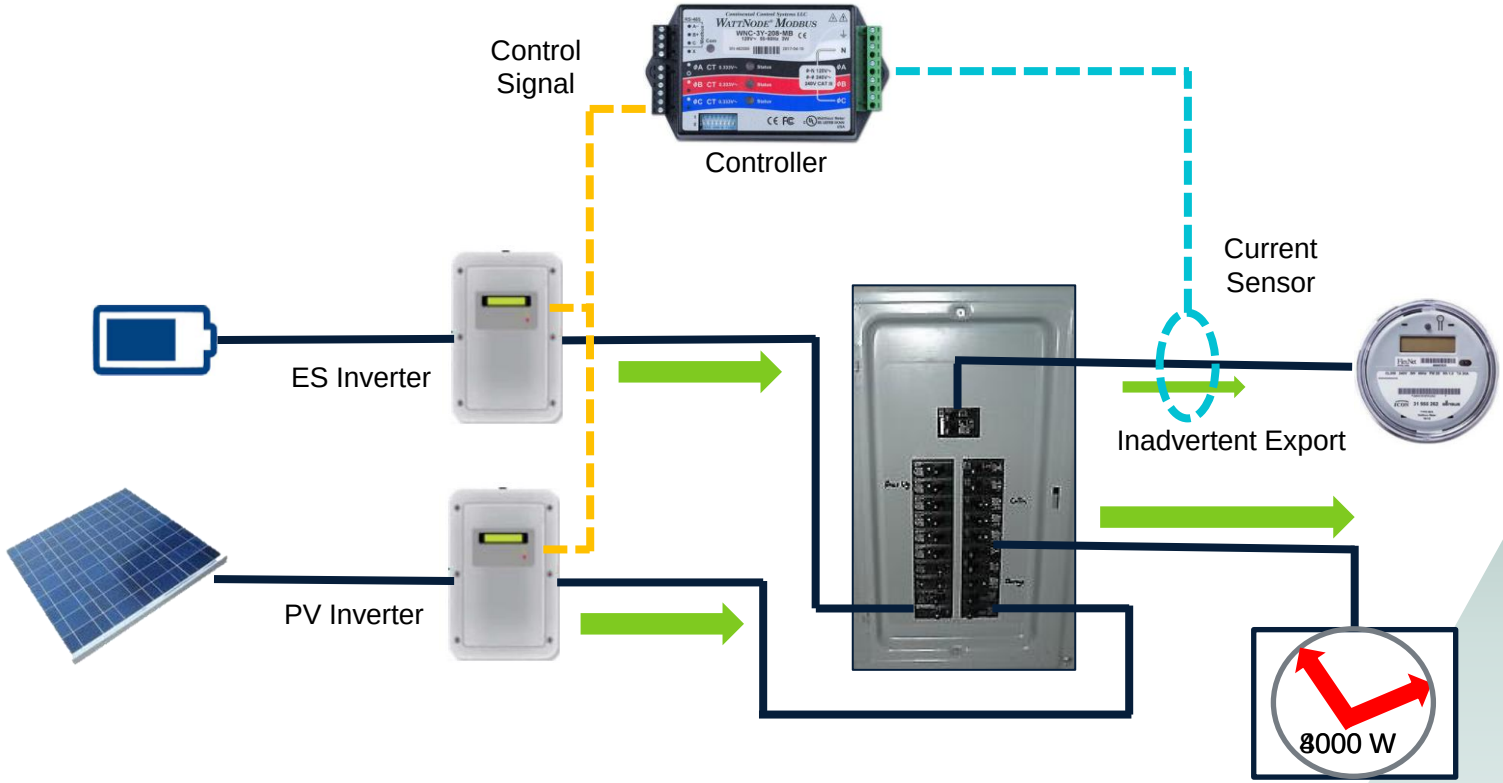
Inadvertent Export Basics

- 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
- Voltage change is main impact
- No impact to transformer lifetime (PNNL report)

Inadvertent Export



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,

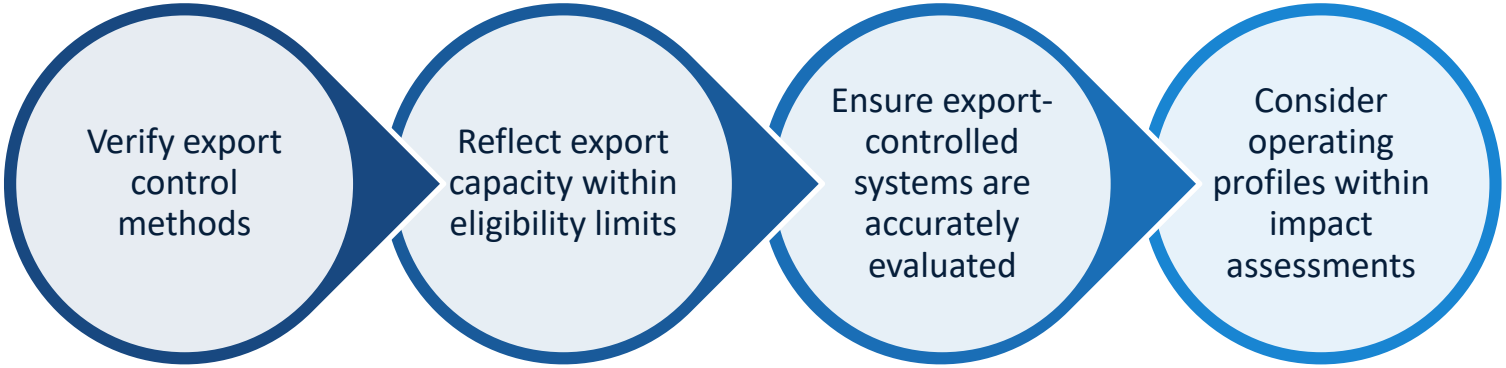
$\Delta \boldsymbol{Q}$ = (DER apparent power Nameplate Rating – Export Capacity) × $\sqrt{(\mathbf{1} - \boldsymbol{PF^2})}$,

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

Toolkit Recommendations



Rules should be revised to better accommodate non and limited-export facilities

Storage Rules in States

State rules that explicitly define and differentiate between the concept of nameplate and export capacity.	State rules that adopted all export limiting concepts (export capacity, nameplate capacity, identified export control methods, identified PCSs as an acceptable export control method)
Maryland	Illinois
Nevada	Maine
Arizona*	Michigan
Colorado*	New Mexico
Hawaii*	Oregon
Massachusetts*	Rhode Island
Minnesota*	

* Several states partially met this best practice by defining export capacity but not nameplate capacity, for example.

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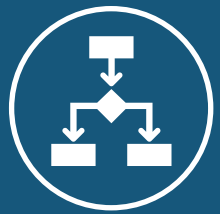
Solution: Allow for System Design Modifications During the Review Process

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

Intro to Scheduling

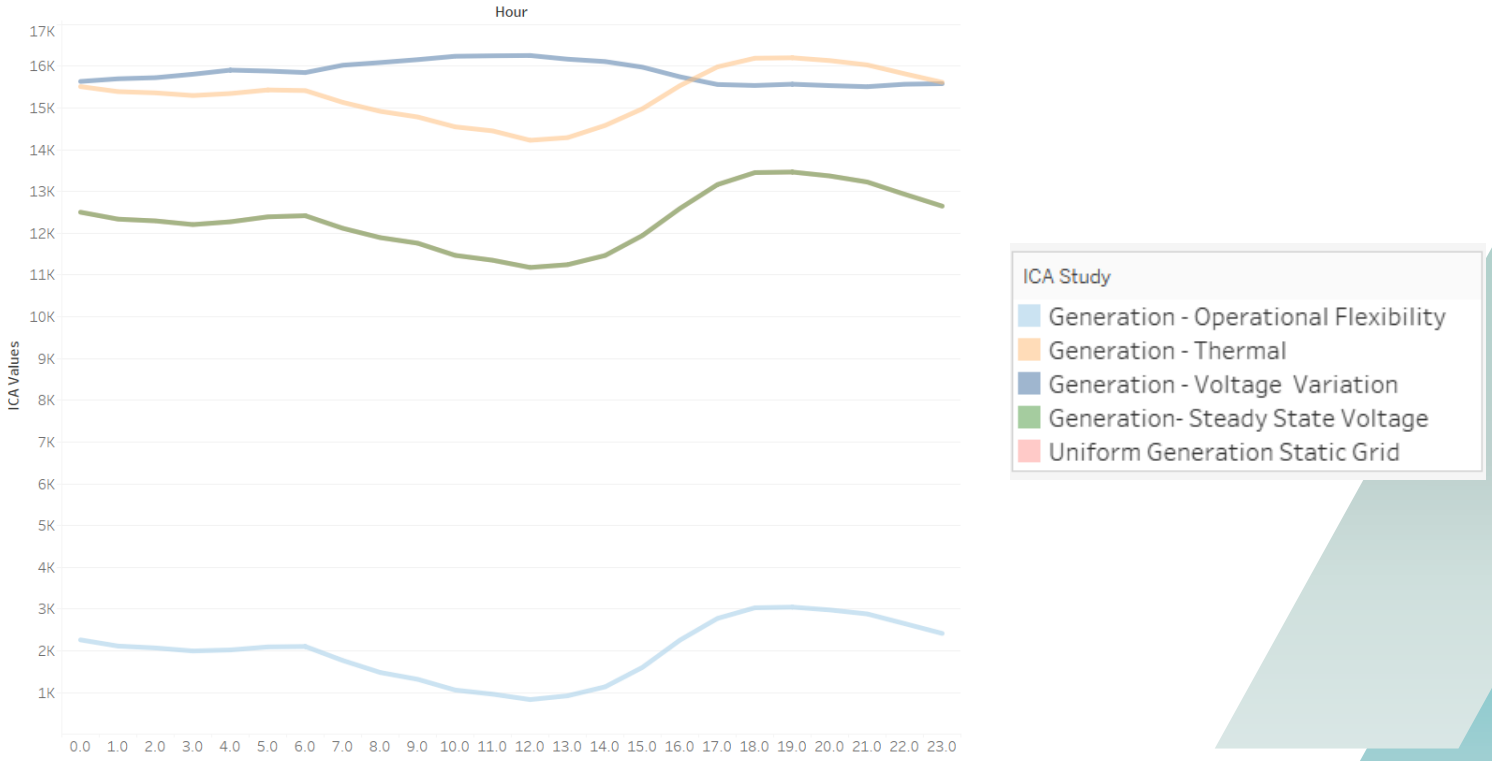
Why Adopt Schedules?

- Hosting capacity varies considerably throughout the day and throughout the year
- Grid constraints often coincide with when there is the least demand (or value) for additional export, and vice versa
- Utilizing schedules may enable a greater amount of existing distribution capacity to be utilized, without upgrades, while also aligning production with energy demand
- Could allow for faster review and interconnection

Advantages of Fixed Schedules

- Provide developers greater certainty on production when compared to more dynamic approaches
- Does not require the use of DERMS or other communication systems, thus could be faster and lower cost to implement
- Can align with rate signals and capture already intended behavior

Hosting Capacity Analysis



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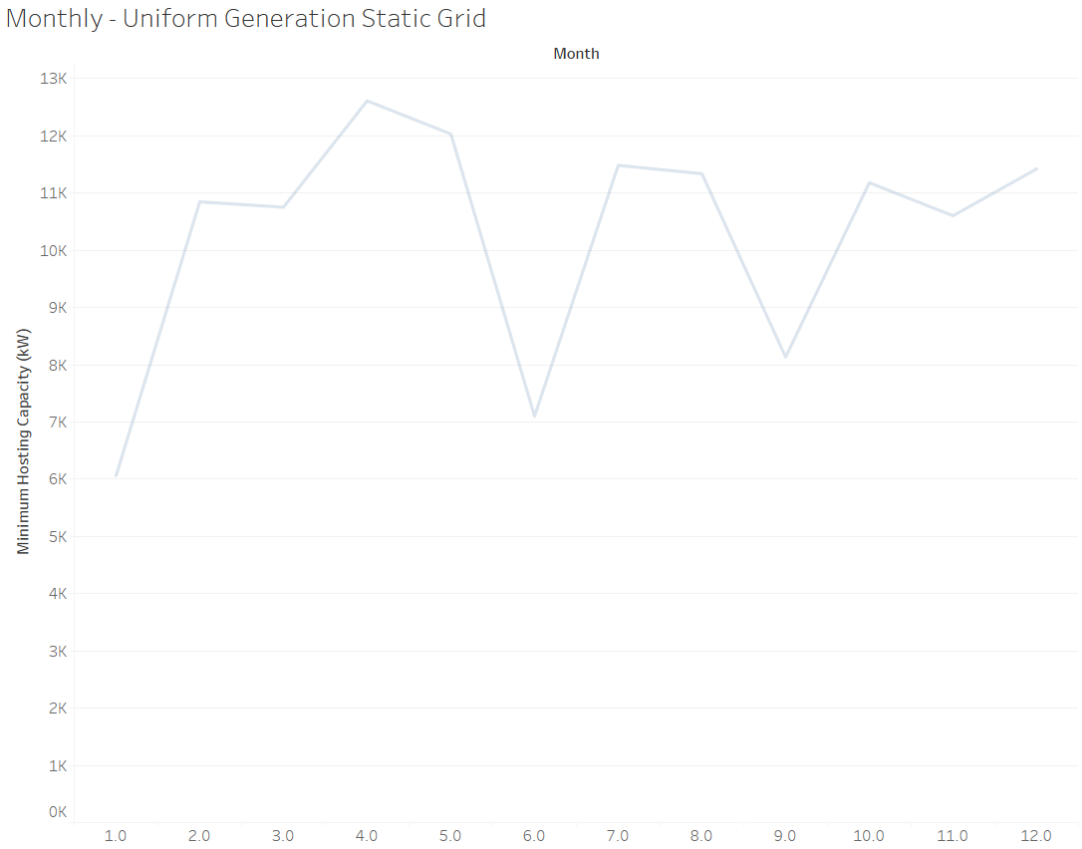
Hosting Capacity Analysis



Hosting Capacity Analysis

- California is implementing a process that would allow applicants to propose “Limited Generation Profiles” that are designed around the HCA profile (-10% buffer)
- Requires an HCA tool, updated regularly, conducted at a granular level (i.e., 576 hours), with detailed results available to potential applicants
- HCA results are based on past year load profile

Schedules based on HCA can Dramatically Expand Capacity

- An example recently developed in California using sample feeder data found that using a schedule could nearly double exports during critical periods when compared to a traditional fixed limit based on the most limiting hour

Export Constraint	Total Annual Energy Exports Possible (GWh)	Average Power Possible (4-9pm, MW)	Energy Ratio	Power Ratio
Current Limit	1,700	190	100%	100%
12-value LGP	2,500	280	150%	150%
288-value LGP	3,100	360	190%	190%

Table courtesy of California Public Advocates

To download the Toolkit, go to:

energystorageinterconnection.org

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