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Interconnection (IX) & Grid Integration for Battery Energy Storage

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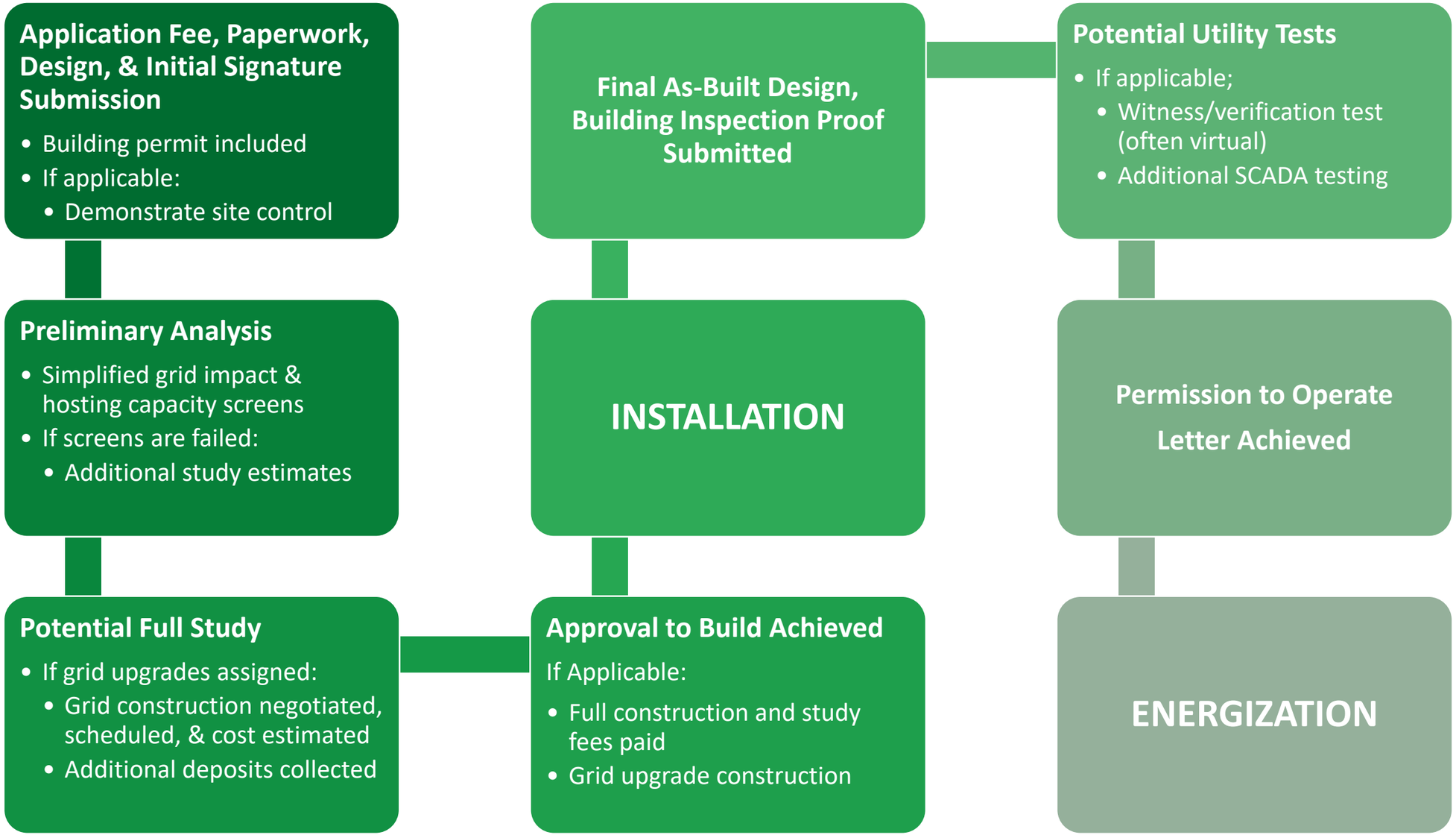
Agenda

- Interconnection Processing
  - Pathways, System Sizing, Power Control Settings
- Challenges and solutions for deploying storage at scale
  - Flexible interconnection and grid services
- *Q&A and discussion: How have interconnection and related challenges impacted your work?*

BESS Interconnection Process

IX processes were built for generators & BESS have few custom pathways available, if any.



Flow chart adapted from: CUNY, 2025 and PNNL, 2025

BESS System Sizing

Fees and studies are typically triggered by “capacity” measurements.
Flow devices like generators and inverters move energy, but do not store it.
Batteries have an extra sizing dimension that can cause confusion.

- **Generators** - rated in MW (peak power output)
- **Inverter** - rated in MW or kVA (power conversion capacity)
- **Battery** - rated in both MW (power) *and* MWh (energy storage)

<u>BESS system size analogy:</u>

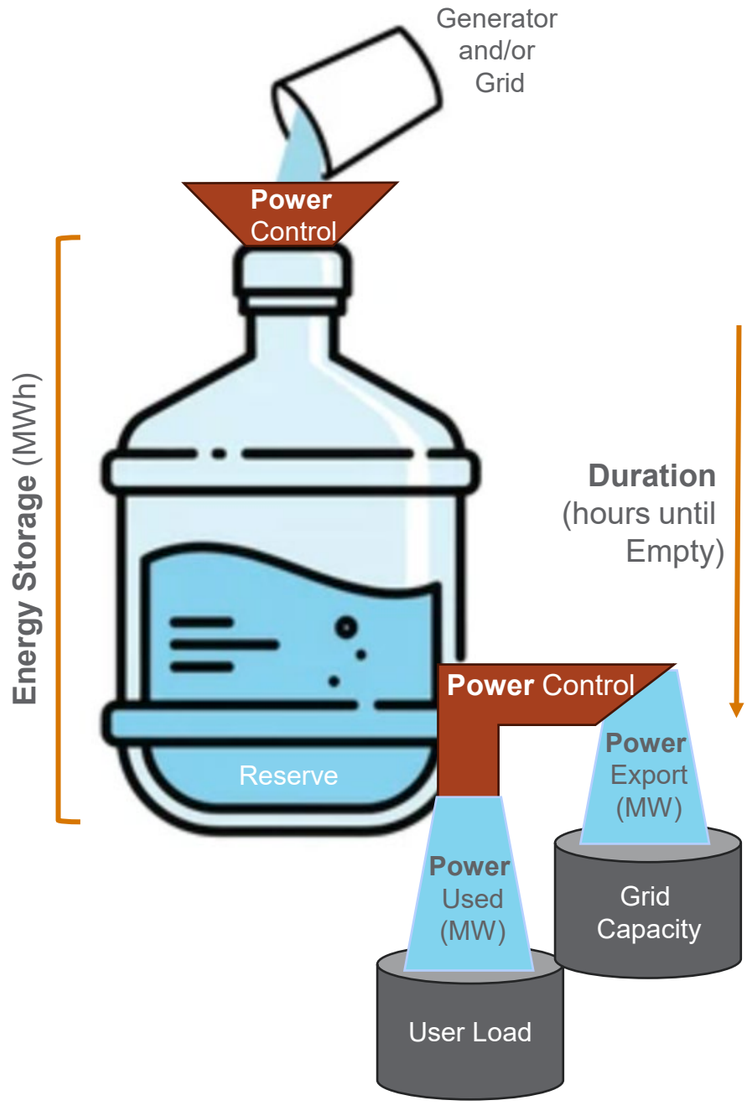
- **Energy Storage (MWh)** = Volume of water in a bucket
- **Power (MW)** = Rate of water flow from dispenser
- **Duration (hours)** = Amount of time to empty

Duration (hours) x Power (MW) = Energy Storage (MWh)

Interconnection typically looks at nameplate “capacity”, but BESS is dynamic

- **Nameplate Rating Capacity –** Max rated power output (kW)
- **Export Capacity –** Actual *power* flow controlled by an inverter (kW)

Power best translates BESS’ real-world electricity exchange rates, but may not fully capture user intent.



Energy	Power	Duration
Same 4MWh BESS	Full (1MW)	4 hours
	Half (500kW)	8 hours

Interconnection Pathways

System size (in MW) is the primary concern for a utility interconnection and is used to classify applications upfront:

- **Simplified Track**: No study is required, but limited screens for issues like grid capacity may occur. These resources may connect to a single- or three-phase service.
  - Maximum system size: 25 to 50kW
- **Fast Track**: Additional screens. Eligibility is determined based on the generator type, generator size, line voltage, and location of the point-of-interconnection.
  - Maximum system size: 50kW to 5 MW
- **Standard Study Track**: For projects that exceed the fast-track threshold or fail the fast-track technical screens. These projects require additional, often customized studies and are likely to trigger grid upgrades.
  - Typical maximum capacity: 5 MW to 10 MW, with exceptions and custom pathways for larger capacities.

Adapted from: PNNL, 2025

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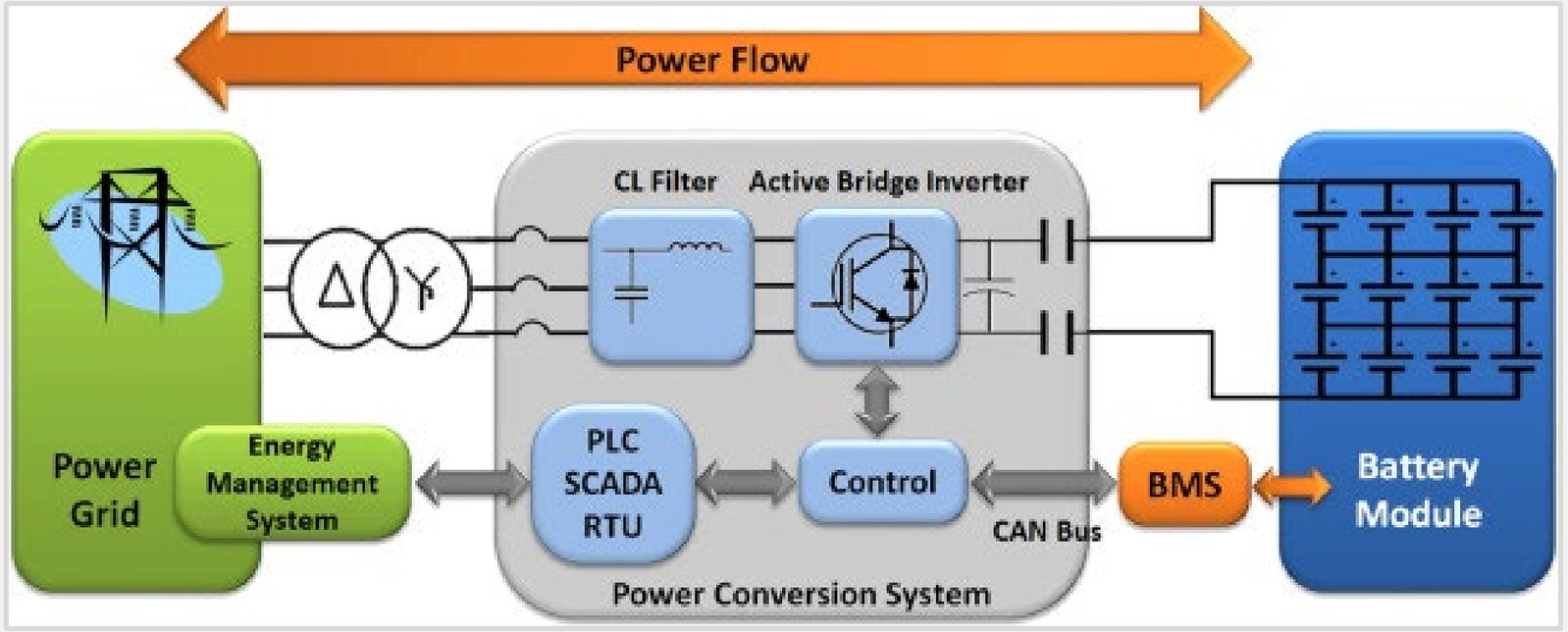
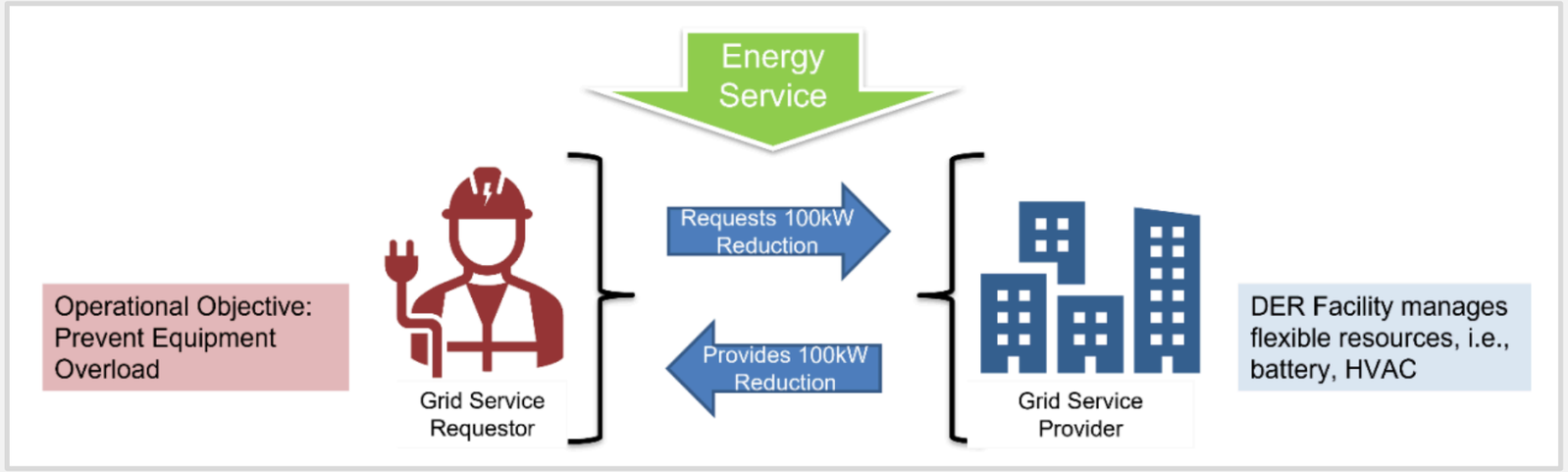
Power Control Settings

Two potential settings can achieve a lot;

- Non-export
  - Backup
  - Self-supply
- Limited export
  - Power Control
  - Voltage Management
  - Frequency Response and Regulation
  - Blackstart



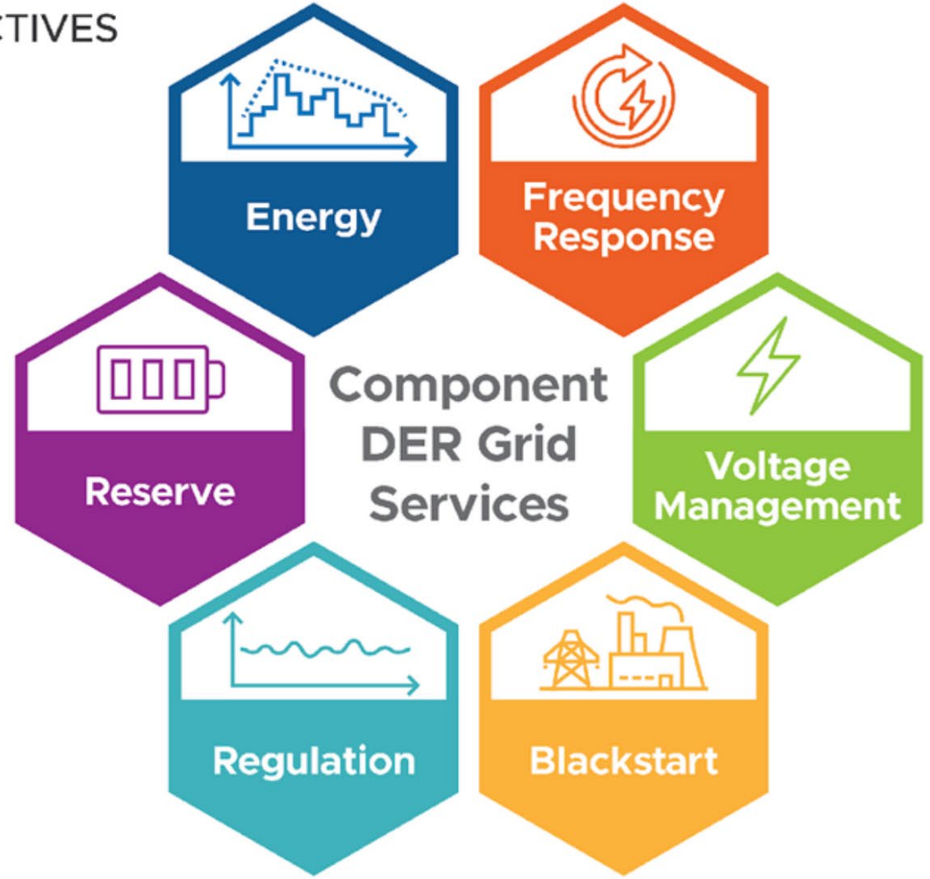


Source: PNNL, 2023

Common Grid Services

PROVIDER OPERATIONAL OBJECTIVES

- Backup Power
- Increased PV Self-Consumption
- Demand Charge Mitigation
- Time Shifting Charging
- TOU Optimization
- Energy Arbitrage



GRID OPERATIONAL OBJECTIVES

- Peak Load Shaving
- Voltage Support
- Frequency Regulation
- Load Shaping
- Spin/Non-Spin Reserve
- Emergency Power

Source: PNNL, 2023

Storage Interconnection Barriers

The 2022 BATRIES Report by the Interstate Renewable Energy Council (IREC) found the following barriers to interconnection:

1. Storage is not included or unclear in many interconnection rules
2. Interconnection rules do not mention acceptable methods for controlling the export
3. Non- and limited-export systems are assessed using unrealistic assumptions, leading to overestimated grid impacts
4. Interconnection rules lack uniform specification for export control equipment response times and the impacts of inadvertent export
5. Interconnection processes do not provide sufficient information on the state of the grid, its hosting capacity constraints, and locations available to interconnect
6. Interconnection processes cannot make system design changes (other than downsizing) to address grid impacts and avoid upgrades
7. States have not updated their interconnection procedures and technical requirements with the most recent standards
8. Interconnection processes lack rules for evaluating operating schedules

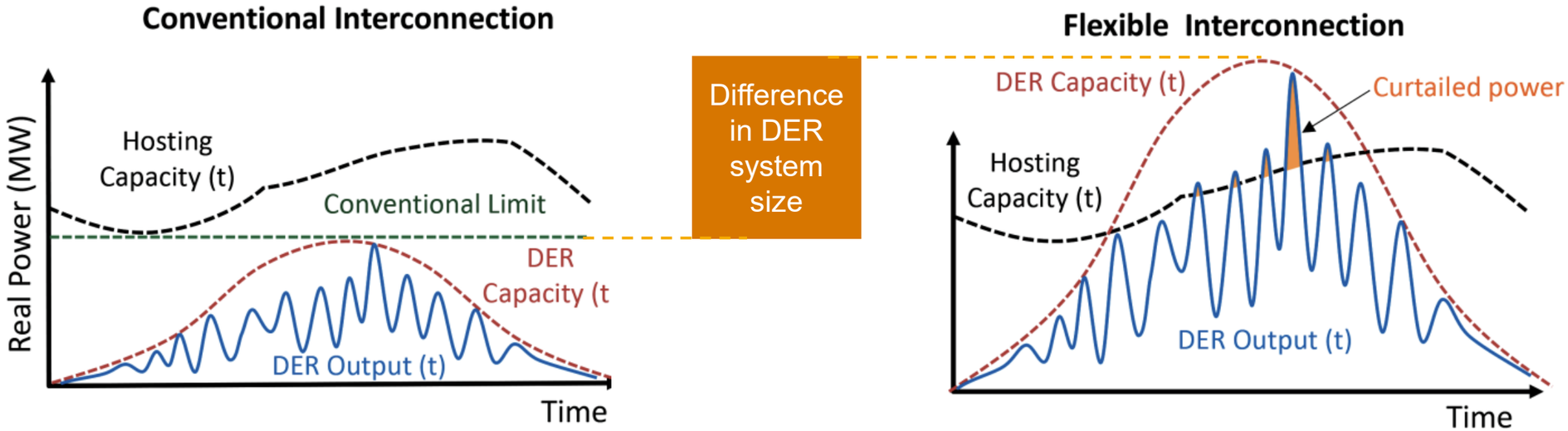
Source: IREC, 2022

RTO/ISO	Capacity in Queue (MW)	Average Months in Queue
CAISO	186,569	43.4
ERCOT	178,957	22.2
ISO-NE	36,230	24.2
MISO	258,934	N/A
NYISO	113,536	24
PJM	165,753	24.4
SPP	120,258	25.1

Conventional vs Flexible Interconnection

Conventional Interconnection (CI) is for free-flowing solar systems whose real power export capacity cannot exceed the lowest range of a grid site's hosting capacity (left).

Flexible Interconnection (FI) is for solar systems that include inverters certified under UL 1741 as '*utility interactive products with grid support functionality*' that use power control systems to operate safely below the full range of a site's grid hosting capacity.



From the image source: EPRI, 2020b: "Under conventional interconnection approaches (left) the proposed system was downsized in order to comply with the site's identified hosting capacity threshold (black dashed line). Whereas, under a flexible interconnection approach (right) the proposed system was built larger and allowed to operate so long as its real power (blue line) is managed by power control systems within a UL 1741 certified inverter to stay below the site's hosting capacity threshold at all times."

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Thank you

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