DER Aggregator Participation Model:
Full Model Design

FERC Order 2222 Team

DISRS
March 9, 2026

Overview

- Issued in 2020, FERC Order 2222 was intended to enable distributed energy resources (DERs) to participate in wholesale electricity markets.
- "DER" refers to a wide swath of distribution-connected resources and includes battery storage, rooftop solar, EVs, and traditional demand response, among others.
- Because individual DERs may be small and unable to participate on their own, Order 2222 allows the *aggregation* of multiple DERs into one market unit.
- PJM has made a series of compliance filings with FERC outlining in detail the proposed components of its DER Aggregator Participation Model.
- Today, all aspects of the model design have been approved by FERC and PJM is working on implementation.

Compliance Timeline

Sept 2020: FERC issued Order 2222 directing all ISOs/RTOs to open their markets to aggregations of DER.

February 2022: PJM filed detailed plan to comply with FO2222.

March 2023: FERC responded and sent PJM back to the drawing board on a number of issues.

September 2023: PJM filed its revised compliance plan.

July 2024: FERC issued Order largely approving PJM's substantive design proposal.

October 2024: PJM filed its revised compliance plan on remaining items.

May 1, 2025: FERC approved all outstanding items.

Implementation Timeline

- **Jan - Dec 2025:** Capacity Market implementation details & manual revisions
- **Jan 21, 2025:** MOPR Certification & DER plans due
- **June 30 - July 7, 2026:** DERs able to offer in 2028/29 BRA under the 2222 model
- **Jan 2026 - Dec 2027:** Energy & Ancillary Services Market implementation details & manual revisions
- **Nov 2026 - Dec 2027:** Energy & Ancillary Services Market development & testing
- **Nov 2027:** Enrollment begins
- **Feb 1, 2028:** Full model go-live

Order 2222 Design

DERA Jurisdiction & Interconnection	Market Design	Coordination	Operations	Settlements
1. Interconnection 2. Market participation agreements 3. Opt-in for small utilities	1. Market participation model 2. Type of technology (homogenous / heterogeneous) 3. Bidding parameters 4. Min./Max. size requirements	1. DER registration 2. EDC coordination 3. Modification to list of resources	1. Locational requirements 2. Distribution factors 3. Telemetry 4. Operational needs	1. Metering configuration 2. Settlement requirements 3. Double counting services 4. Use case development

DERA Jurisdiction & Interconnection

DERA Jurisdiction & Interconnection	
Interconnection	• PJM will not have jurisdiction of the interconnection of DER resources • DER owners will utilize the applicable state interconnection process without entering the PJM queue, if solely participating in a DERA
PJM Planning Requirements	• Data Requirements for Planning defined for necessary PJM study and reliability
Market Participation Agreement	• Attestation that DERA is compliant with tariffs/operating procedures/rules of distribution utility and RERRA • Reviewing parties to Market Participation Agreement
Jurisdiction	• DER Aggregator must be PJM Member, execute the DAPSA, and have Market-Based Rate Authority.
Opt-in for Small Utilities	• Small EDCs (< 4 million MWh) must opt-in to permit their customers to participate in the DER model. EDC to provide opt-in evidence & PJM to post publicly.
DR Opt-Out	• Existing rules for DR opt-out to apply to DER Aggregations containing DR

Interconnection Process

- PJM will not have jurisdiction over the interconnection of resources in the DER Model. DER owners will utilize the applicable state interconnection process without entering the PJM queue.

- If a DER does not satisfy the requirements of the DER Model (e.g., it is >5 MW), it will need to enter the PJM queue to participate in the wholesale market.
  - Resources that go through the queue will not participate in PJM Markets under the Order 2222 DER Model, but rather under the rules and requirements of the technology type.

Capacity Interconnection Rights

- Resources in the DER Model will not receive CIRs from PJM. They may still participate in the capacity market by following the rules and requirements of the DER Model as outlined in Manual 18.

Status Quo Accounting for BTM DERs

- DER activity on distribution is currently represented as a reduction to load in the transmission models (DER activity is netter against load).
- Netting may be sufficient for low levels of DER but will be inadequate if DERA spurs growth as intended by Order 2222.
- Netted generation and loads are not visible to PJM's Planning analyses
  - Generation and load have different characteristics;
  - Differences impact load flow analyses;
- Netting introduces reliability risks in scenarios where PJM must serve load
- NERC has issued several recent recommendations against netting

Accounting for DERs in the DER Model

- DER in the DER Model will be explicitly modeled in RTEP, rather than simply netted against load.
- To do so, PJM will use the information provided for each DER during the registration process, including:
  - Address
  - Technology (solar, battery, landfill gas, wind, hybrid, etc.)
  - Maximum AC output (gross nameplate capability)
  - PJM Planning Model Bus ID
  - Ride through capability enabled? Y/N
  - Voltage control enabled? Y/N
- Both Aggregator and EDC will verify data annually

Market-Based Rate Authority

- DER Aggregators intending to sell energy, capacity, or ancillary services at market-based rates will likely need Market-Based Rate Authority. (DER Aggregators should consult with their respective FERC counsel.)
- Order 2222 will not require individual DERs within an aggregation to have Market-Based Rate Authority.

PJM Membership

- DER Aggregators will need to be a PJM member to operate in PJM Markets.
  - DER physical owners will not need PJM membership.
- DER Aggregators will be subject to credit requirements, based on the markets in which they are participating

DERs NERC Registered?

- Unlikely - does not meet the 75MVA threshold or the 100kV connection threshold (NERC ROP, Appendices 2 & 5B).
  - Questions should be referred to DER Aggregator's FERC counsel regarding specific configurations.
- This could change based on specific resources and further NERC advancement in DER activities.

Market Participation Agreements

- The DER Aggregator must execute the *pro forma* DER Aggregator Participation Service Agreement (DAPSA) under the Tariff, Attachment N-4.
- PJM and the DER Aggregator are party to agreement.
- The DAPSA is an attestation that DER Aggregator is compliant with the tariffs/operating procedures/rules of the distribution utility and the RERRA.
- The DAPSA must be executed ahead of the DER Aggregator's participation in PJM Markets.

Dispute Resolution

Dispute	Disputing Party	Adjudicated by FERC	Adjudicated by States
Market Entry for DERA – denied	DER Aggregator	X	X
Market Entry for DERA – approved	Utility	X	
Override for reliability, safety, or other needs by utility, resulting in PJM Market penalty for DERA	DER Aggregator		X
Override, choice of assets to curtail by utility, resulting in Market penalty for DERA	DER Aggregator		X
Compensation to DERs from DER Aggregator	DER Owners		X
Inaccurate Market compensation or data submission discrepancy	DER Aggregator	X	
Retail/Wholesale double counting – denied participation in PJM Market(s)	DER Aggregator	X	X
Retail/Wholesale double counting – approved participation in PJM Market(s)	Utility	X	X
PJM planning upgrades due to DER penetration	Load	X	

Small Utility Opt-In/DR Opt-Out

Small Utility Opt-In

- An EDC that opts in to allowing its customers to participate in the DER Model should provide evidence of the opt-in decision to PJM.
  - The EDC should email the evidence (or a public link to the evidence) to PJM, which will be posted on pjm.com.
- If the DER Aggregator or RERRA do not see the opt-in evidence posted, they should contact PJM and provide a copy of the communication sent to the EDC.
- Transition period to be proposed for small utilities that do not opt-in and transition to a large utility (utilities that distributed more than 4 million MWh).

DR Opt-Out

- PJM will apply the existing DR opt-out process to aggregations of demand response that seek to participate in the DER Model.

Market Design	
Market Participation Model	• New, Tariff-defined “DER Aggregator Market Participation Model” • DER Aggregations are eligible to provide all Energy, Capacity and Ancillary Services, where technically capable. • Component DERs must aggregate within the same pnode to form a DERA in the energy market (except in the limited multi-nodal option). • Broader geographic aggregation available based on Capacity and/or Ancillary Services market participation.
Type of Technology	• Any distribution connected technology, homogenous and heterogeneous aggregations
Bidding Parameters	• Commitment variables not required • ESR model parameters available to DERAs with ESRs (e.g., can be committed and set price on negative offer curve)
Size Requirements	• Maximum size requirements on a Component DER is 5 MW • Minimum size requirement of 0.1 MW for DER Aggregation

Market Design	
Capacity	• No capacity market must-offer requirement. • Planned DER Capacity Aggregation Resources will be eligible to participate. • DER Capacity Aggregation Resources will be defined within a LDA.
Energy	• No commitment model • DERAs can be dispatched by PJM by providing a cost offer to PJM or can self-schedule under a no-dispatch model • Day-Ahead Energy Market must-offer requirements for DERA (based on underlying DER)
Ancillary Services	• Eligible for regulation and reserves (sync and secondary) • Will not be used for Reactive Services
Double Counting	• DER cannot provide the same product/service at retail and wholesale

Key Terms

The **DER Aggregator Participation Model** allows DER aggregations to participate in PJM wholesale markets where technically capable.

"Component DER" is a resource that is located on a distribution system that participates in the Energy, capacity and/or ancillary services markets of PJM through the DER Aggregator Participation Model. A Component DER may not exceed 5 MW. A Component DER is associated with one EDC account number and may include several "DER."

"DER Aggregation Resource (DERA)" comprises one or more Component DER and is the "market unit" used by a DER Aggregator to participate in PJM's wholesale market. A DER Aggregation Resource must be at least 100 kW.

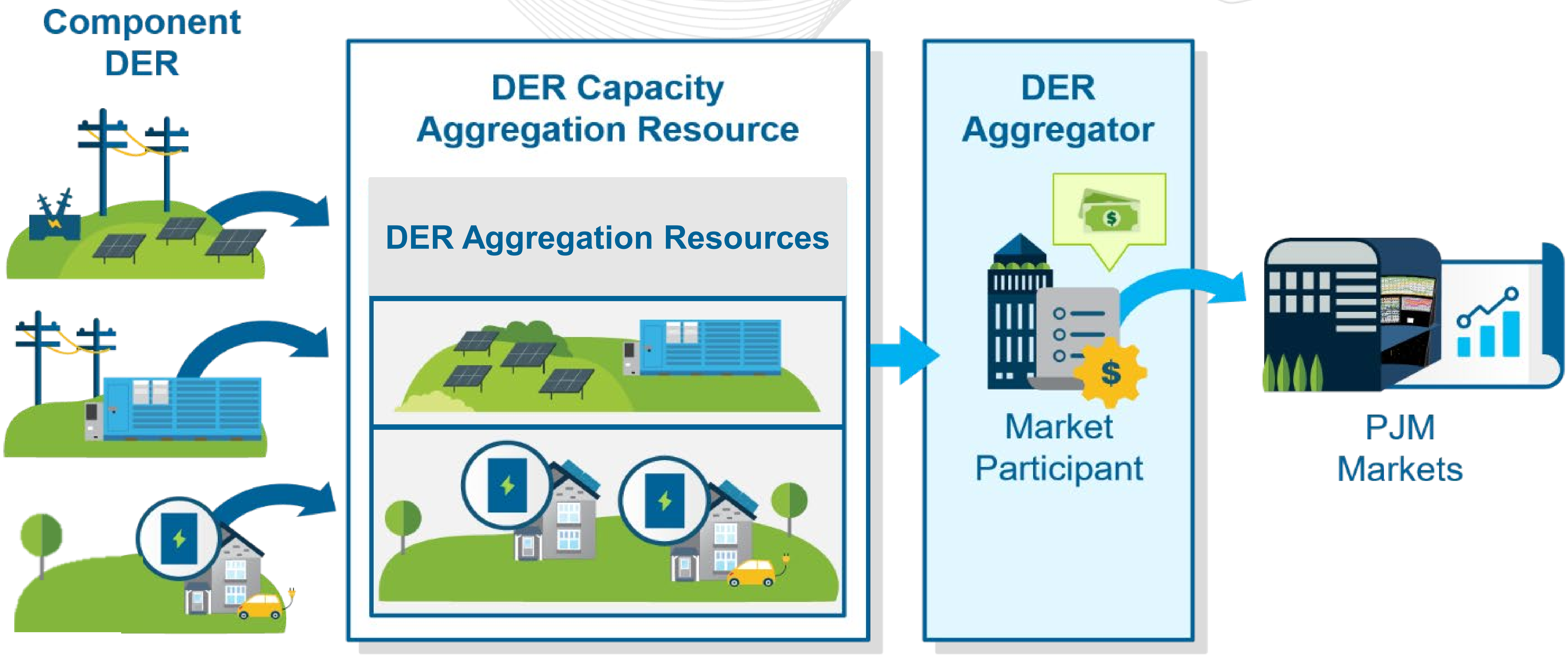
"DER Capacity Aggregation Resource" comprises one or more DER Aggregation Resource that participates in the Reliability Pricing Model.

"DER Aggregator" is the entity that aggregates one or more DER for purposes of participation in the capacity, Energy and/or ancillary service markets of the RTOs/ISOs.

Market Participation Model

- DERs can participate in PJM Markets under existing market models, or the new "DER Aggregator Participation Model".
- Existing market models available to DERs (if they qualify) include: Generator Model, Energy Storage Resource Model, Hybrid Resource Model, Demand Response Model
- Under the DER Aggregator Participation Model:
  - Individual premises/facilities ("Component DER") can combine to form one market unit ("DER Aggregation Resource") to participate in PJM Markets.
    - The DER Aggregation Resource may also comprise of just one Component DER.
  - DER aggregations can be homogenous (one technology type) or heterogeneous (multiple technology types).

Model Framework



- DER Aggregation Resources will be able to participate in Energy and Ancillary Services Markets.
  - Aggregations participating in the energy market will meet the nodal locational requirement as described later in this presentation.
  - Ancillary Service Only aggregations can be aggregated more broadly, as described later in this presentation.
  - DERAs can further aggregate for regulation performance.
- DER Capacity Aggregation Resource will be able to participate in the Capacity Market.
  - One or more DER Aggregation Resources can make up a DER Capacity Aggregation Resource.
  - Location requirements will be based on zonal/sub-zonal LDA requirements in the RPM.

Min/Max Size Requirements

Component DER

- There is no minimum size requirement for an individual Component DER.
- A Component DER cannot exceed 5 MW.
  - PJM needs to ensure that larger resources are studied by for transmission impacts and additional visibility into resource operations are provided.

DER Aggregation Resource

- The minimum size of a DER Aggregation Resource is 100 kW.
- There is no maximum size for a DER Aggregation Resource.

Market Participation Model Summary

Requirements	Capacity	Energy	Ancillary Services Only
Locational Requirement	Aggregate multiple DERAs up to zonal/ sub-zonal LDA	Aggregate Component DER up to primary location (nodal)	Aggregate Component DER up to state/ EDC/TO zone level
Size – DERA min and max	100kW min, no max	100kW min, no max	100kW min, no max

Market Participation Model – Managing Aggregations

DER	Primary transmission location	Aggregations for Energy & Ancillary	LDA	Aggregations for Capacity*	Aggregations for Regulation Performance^
DER1	Node A	DERA 1	LDA 1	DERA CP 1	DERA 1, 2 & 3
DER2	Node A	DERA 1	LDA 1	DERA CP 1	DERA 1, 2 & 3
DER3	Node A	DERA 1	LDA 1	DERA CP 1	DERA 1, 2 & 3
DER4	Node A	DERA 1	LDA 1	DERA CP 1	DERA 1, 2 & 3
DER5	Node B	DERA 2	LDA 1	DERA CP 1	DERA 1, 2 & 3
DER6	Node C	DERA 3	LDA 1	DERA CP 1	DERA 1, 2 & 3

- *Meets LDA requirements in Capacity
- ^Meets performance group requirements for regulation

Capacity Market

- DER Capacity Aggregation Resources may voluntarily offer into the Capacity Market and are not subject to RPM Must Offer Requirement or Notie of Intent.
- DER Capacity Aggregation Resources will be assigned to a zone/sub-zonal LDA based on the location of underlying Component DERs.
- Offer price may be subject to MOPR and MSOC based on the underlying DER technology type.
- All resources with a capacity commitment will have an energy must offer requirement.
  – No “emergency” DER concept in the DER Model
- The reserves must offer requirement for resources with a capacity commitment will depend on the underlying DER technology type.

DER Plan

- To participate in a capacity auction, DER Aggregators must submit a DER Plan at least 30 days ahead of the auction date.
  – If subject to MOPR, the DER Plan must be submitted together with the MOPR certification by the MOPR certification deadline (typically 150 days ahead of the auction).
  – Auction schedules are available here.
- The DER Plan provides details on the resource, including technology type, capability, zone/subzone LDA, description of program or equipment type, etc.
- DER Plans are to be submitted in Capacity Exchange.
- DER Plans may consist of Planned and/or Existing DER.
  – All DER will be considered Planned until registrations are approved.

Planned vs. Existing DER in DER Plan

Existing	Planned
I. Currently have capability to provide capacity and will provide the capability for DY of RPM Auction II. Existing MWs based on pre-registrations in Capacity Exchange. Pre-registrations are based on current DR Hub registrations III. No Credit Requirement	I. Location for the Component DER is not currently registered and approved II. Credit Requirement is Pre-Clearing BRA Credit Rate * Number of Planned MWs

DER Aggregator is required to provide Officer Certification attesting to the fact that MWs will be delivered in the DY (similar to DR Plan)

Capacity Accreditation

- Capacity value is assessed at the individual DER level based on the applicable method for the technology type. The accreditation of a DER Capacity Aggregation Resource is the sum of the capacity values of the underlying DER.
- Committed capacity is determined at the DER Capacity Aggregation Resource level.
- Ahead of the Delivery Year, a DER Aggregator will register one or more DER Aggregation Resources* to fulfill the capacity commitment of a DER Capacity Aggregation Resource.
- The DER Aggregator may have more registered capacity value than is needed to satisfy the capacity resource commitment.

* A DER Aggregation Resource, or DERA, is the energy/AS market unit.

MOPR/MSOC

- All injecting resources will be subject to the MOPR/MSOC based on the underlying technology type.
  - Demand Response is not subject to the MOPR/MSOC.
- MOPR (planned or existing resources)
  - The DER Aggregator must submit a MOPR certification asserting no state conditioned support, or request a unit-specific MOPR (may use weighted average MOPR price by technology).
  - In the absence of the above, the resource will not be eligible to participate in the auction.
- MSOC (existing resources)
  - The capacity resource will be a price taker ($0 offer price cap) unless a unit specific MSOC is requested and approved.
    - Segment-based MSOC by technology
    - Weighted average MSOC

Non-Performance Assessment

- Daily Deficiency:
  - Shortfall determined based on sum of the nominated UCAP on registrations tied to the capacity resource compared to that resource's UCAP capacity commitment on each day
  - Deficiency rate is same as DR and Generation today
- Non-Performance Assessment (in event of a PAI):
  - Subject to Non-Performance Charge if underperform and subject to Bonus Performance Credit if over-perform
  - Expected and Actual Performance will be calculated at DERA level (energy market resource level) subject to existing technology specific rules
  - Excusals for approved outages subject to existing technology specific rules
    - No excusals for utility overrides
  - Netting of performance will be available for DERAs within the capacity resource
    - No netting of performance across DERA CP Resources in a market seller account

- All components of a DER Capacity Aggregation Resource are required to test simultaneously at least once per year; the DER Aggregator may perform an unlimited number of tests.
- The Aggregator must notify the relevant EDC of a test at least 7 days in advance.
- Test Failure Charge for any shortfall, multiplied by the DER Capacity Aggregation Resource Test Failure Charge rate.
  - The Test Failure Charge rate will equal the Weighted Daily Revenue Rate in the relevant Zone plus the greater of (0.20 times the Weighted Daily Revenue Rate in such Zone for the product(s) tested or $20/MW-day).
  - Test Failure Charge revenue will be distributed to LSEs that were charged a Locational Reliability Charge, pro-rata based on the LSE's Daily Unforced Capacity Obligations.
- Gen Rating Test – Not Applicable
- Gen Operational Test – Not Applicable

Energy Model Comparisons

Model	Gen	ESR	Econ DR	DER Model
Cost Offers	Yes	Yes	No	Yes
Self-Schedule	Yes	Yes, can schedule at 0 MW	Yes	Yes, can schedule at 0 MW
Must Offer	Yes	Yes	No	Yes
Dispatchable	Yes	Yes	Yes	Yes
Wholesale Charging Energy	No	Yes	No	No

- For dispatchable resources in the DER Model, the following parameters will be available
  - Offer curve, MW/price pairs
  - Economic Minimum/Maximum
  - Emergency Minimum/Maximum
  - Ramp Rate

Energy Market Model

- The DER Model is a self-scheduled model
  - PJM will not make commitment decisions for DERAs.
  - A DERA may self-schedule at 0MW and provide a dispatchable range for economic dispatch.
- Two options for Energy Dispatch available under DERA Energy Market Model
  - Option 1: DERA will participate in Energy Market under a no-commitment, no-dispatch model (eco min = eco max)
  - Option 2: DERA will participate in Energy Market under a no-commitment model, PJM dispatch available

Energy Market Model

- no-commitment, no-dispatch
  - DERAs will be expected to self-schedule energy into the DA and RT energy markets based on their forecasted availability.
  - DERAs will be required to submit $0 cost based offers.
  - DERAs will not be able to set price or be eligible for LOC/make whole.
- no-commitment, PJM dispatch
  - Homogeneous DER aggregations will follow Manual 15 language and construct FCP for non-zero cost based offers.
  - Heterogeneous DER aggregations will have zero cost based offers. There is an opportunity to develop cost based offers in the future at the Cost Development Subcommittee.
  - DERAs will be able to set price and be eligible for LOC/make whole.

Energy Market Model

Aggregation	Energy Must Offer	Cost Offer*
Homogenous – front of meter DER (gen, solar, battery)	Gen = ICAP Solar/ESR = MW offer may vary	Follow Manual 15 for non-zero cost offers
Homogenous – DR	MW offer may vary	Cost Offers = $0
Homogenous – Continuous DER^	MW offer may vary	Cost Offers = $0
Heterogeneous – DR, Continuous DER, etc.	MW offer may vary	Cost Offers = $0

^ Continuous DER = a retail premise with both load reduction and injection capability

* Stakeholders may work through the Cost Development Subcommittee to develop non-zero cost offers for inclusion in Manual 15.

Ancillary Services Market Model

- DER Aggregation Resources will be allowed to provide Regulation and Reserves, where technically capable.
- DERAs will be eligible to offer resources into Black Start RFPs for consideration on Black Start Service. However, **PJM believes it would be unlikely DERAs would qualify for Black Start and may pose concerns for distribution reliability.**
  - DERAs would be evaluated on a case-by-case basis based on RFP response.
- DERAs will not be considered for Reactive Support or required to provide VAR data to PJM.

Reserves

- DERAs committed for capacity have a reserves must offer requirement based on the rules for the underlying technology type.
- DERAs without a capacity commitment may provide reserves based on the rules of the underlying technology type.
- DERAs are eligible to provide synchronized reserves.
- DERAs are ineligible to provide non-synchronized reserves.
  - DERAs will be self-committing into PJM’s Market and therefore will be considered synchronized when self-committed and offline/unavailable when not self-committed.
- DERAs will be eligible to provide secondary reserves given they will have a valid energy offer.
- DERAs will be able to provide “Reserves Only” (no energy schedule).

Regulation

- DERAs are eligible to provide regulation service
  - DERAs will follow the same business rules as detailed in Manual 11 Section 3 and testing requirements as detailed in Manual 12 Section 4.5 for regulation.
- DERAs can participate in Regulation as a stand-alone aggregation, or utilize performance groups to aggregate performance over multiple aggregation as outlined in Manual 12, Section 4.5.7.
  - Existing rules for the formation of performance groups apply to DERAs providing regulation
- DERAs will be able to provide “Regulation Only” (no energy schedule).

Double Counting

- DER cannot provide the same products/services at the retail and wholesale level.
- A single Component DER cannot be registered with multiple DER Aggregators or provide wholesale market services to PJM via more than one market model.
- Net-Energy Metering (NEM):
  - Generally, injections at a NEM premise cannot provide energy to PJM as these are already being provided to the EDC.
    - Because the DER cannot provide energy, it cannot meet the energy must offer requirement for a capacity resource and therefore cannot provide capacity to PJM.
  - Injections at a NEM premise can provide Ancillary Services to PJM as these are typically not provided to the utility.
  - The check for double counting will be implemented during the utility review process and will be on a utility-by-utility basis to capture different NEM requirements.

Double Counting Matrix

Current Program		DER Model[1] Capacity	Energy	Ancillary Services
None	None	✓	✓	✓
Wholesale	Demand Response (Economic or LM)	⊘	⊘	⊘
	Peak Shaving Adjustment	⊘	⊘	⊘
	Price Responsive Demand	⊘	⊘	⊘
Retail	Retail Tariff Programs	*Varies, based on products/services provided at retail.*		
	NEM: Load Reductions	✓	✓	✓
	NEM: Injections[2]	⊘ [3]	⊘	✓

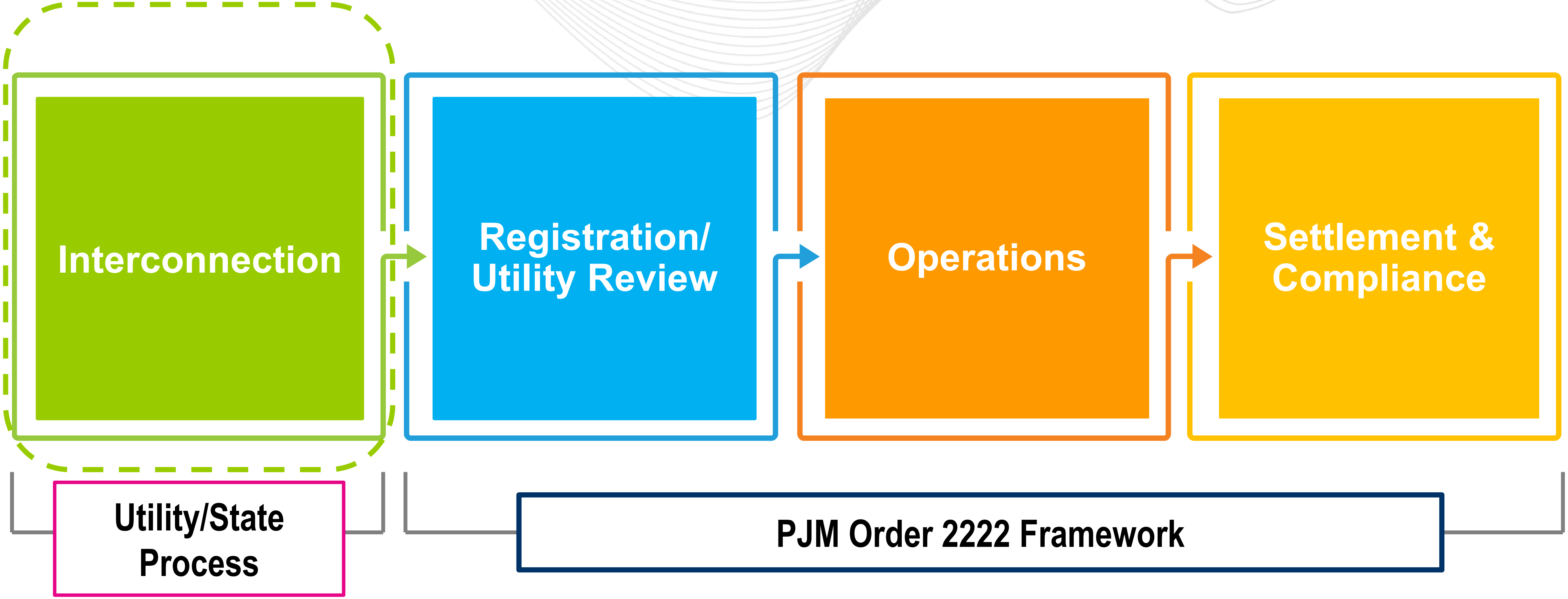
[1] PJM's double counting rules are enumerated in Tariff, Attachment K-Appendix, Section 1.4B(b) and (h).

[2] This summary is based on existing Net Energy Metering tariffs. If these change in the future, the double counting assessment may be different.

[3] While capacity may not be "provided" at the retail level—and, as such, there is no double counting of products or services—the inability to provide energy to PJM precludes the resource from participating in the capacity market as it would not be able to meet the energy must offer requirement.

Coordination	
DER Registration	• Utility Review Process • 60 Day timeframe for review • Addresses necessary review, data submissions and studies required
Modification of List of Resources	• Adding or Removing resources from a DERA will require a re-review of the aggregation for market participation • 60 Day timeframe for review
EDC Coordination	• Communications necessary for safety and reliability of the transmission and distribution systems • Overrides

EDC Coordination- DERA Participation



- Resources will go through their applicable state interconnection process prior to entering the PJM registration process
  - Valid State IA will be needed for each underlying DER to operate as part of a DERA
  - DERs will be required to follow all requirements within State IA
  - A valid State IA will not be required for Planned DER offering into forward capacity auctions
    - Interconnection agreements would still need to be in place prior to delivery year and DERA going operational.

EDC Coordination- DERA Participation

Interconnection → DER Registration/ Utility Review Process → Operations → Performance Compliance & Settlements

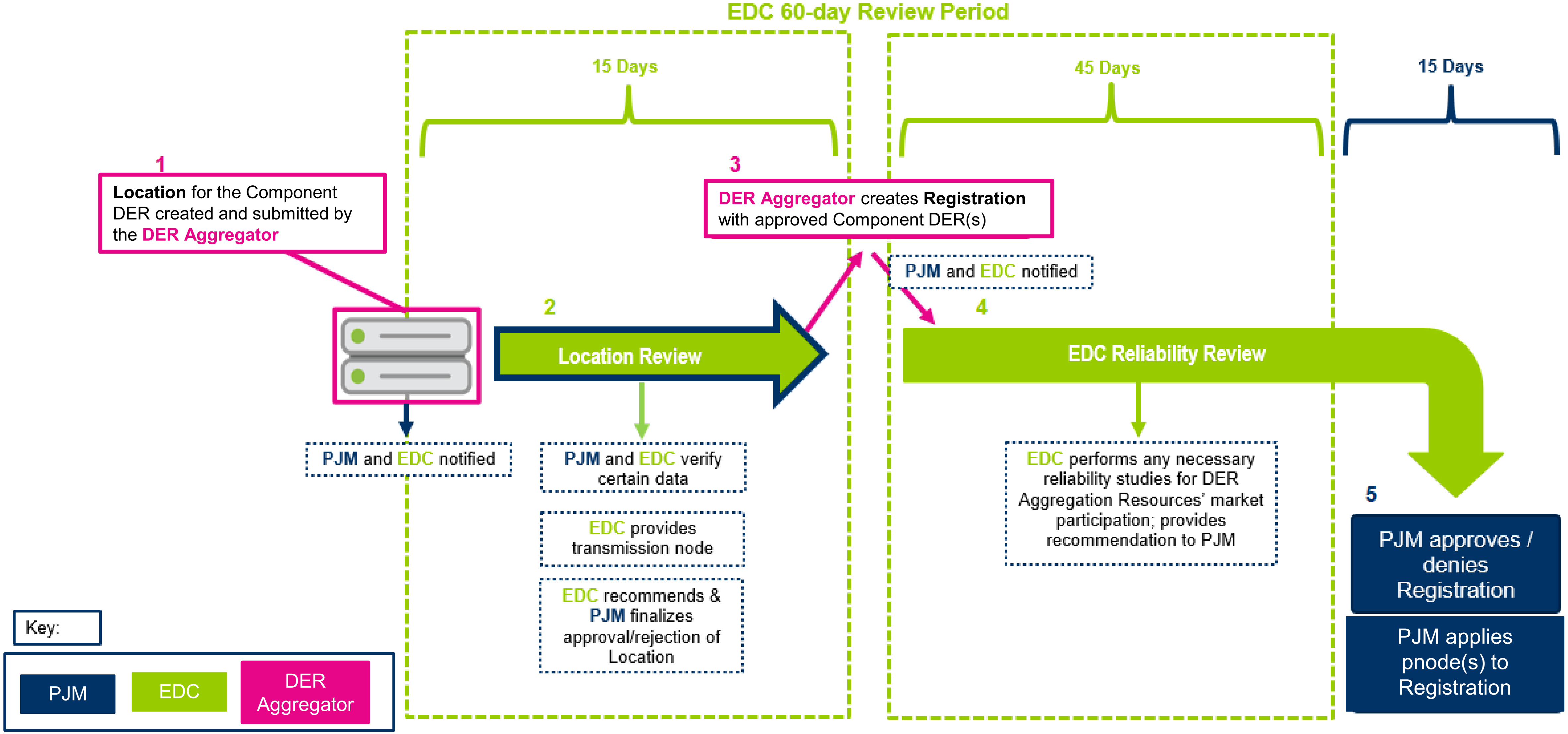
Utility/State Process

PJM Order 2222 Framework

Information & Data Requirements

- PJM will rely on DR Hub—the application currently used to manage DR resources—to manager DER aggregations.
- DER Aggregators will use DR Hub to create “locations” for individual Component DER and “registrations” for DER Aggregation Resources.
  - DER Aggregation Resources will comprise of one or more Component DER.
- For the most up-to-date list of the information and data requirements please see here.

Utility Review Process & Timeline



- DER Aggregators will be required to complete several additional items prior to operations in PJM. These can be working in parallel/during registration process or after registration process.
  - DERA <> PJM telemetry set up
  - Market Gateway account
  - Power Meter verification
  - Market testing

Roles & Responsibilities

RERRA

- Small utility opt-in evidence
- Large utility opt-out evidence for Demand Response
- Additional DER requirements, if applicable, managed through state/utility interconnection

Aggregator

- Responsible for complying with all PJM business rules
- Registers Component DER & and creates DER aggregations.
- PJM Member & Signs Market Participation Agreement
- Participates in PJM Markets

EDC

- Review Component DER locations for accuracy
- Provide additional data for planning & market modeling
- Conduct reliability review of aggregation
- Recommends approval/denial of locations and registrations

PJM

- Reviews DERA registration for completeness
- Establishes telemetry for DERA and verifies meter
- DERA Market modeling and readiness
- Approves/denies registration
- Dispute resolution
- Signs Market Participation Agreement

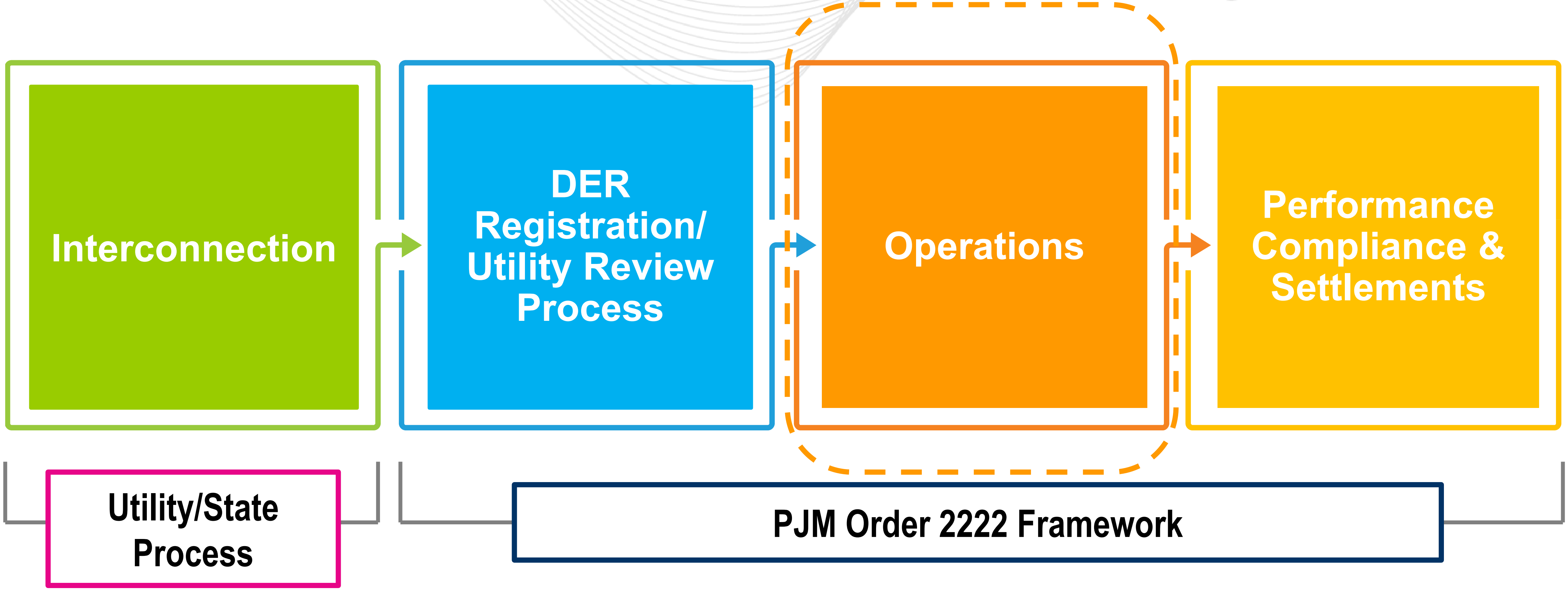
LSE

- (LSE) Notified that LSE customers are included in registration

Modification to List of Resources

- A DER Aggregator must notify PJM of any updates to the individual Component DER, the inventory of Component DER that make up an aggregation, or to the list of market services provided by the DER Aggregation Resource.
  - An update will not require re-registering existing Component DER within the approved DER Aggregation Resource.
- Modifications to an existing DER Aggregation Resource, or components thereof, will re-trigger the 60-day review period.
  - The DER Aggregator may continue to participate in PJM Markets using its existing approved DER Aggregation Resource during the course of this review
- The inventory of Component DER within an aggregation that is linked to a DER Capacity Aggregation Resource may not be modified during the course of the applicable Delivery Year.

EDC Coordination - DERA Participation



Distribution System Reliability

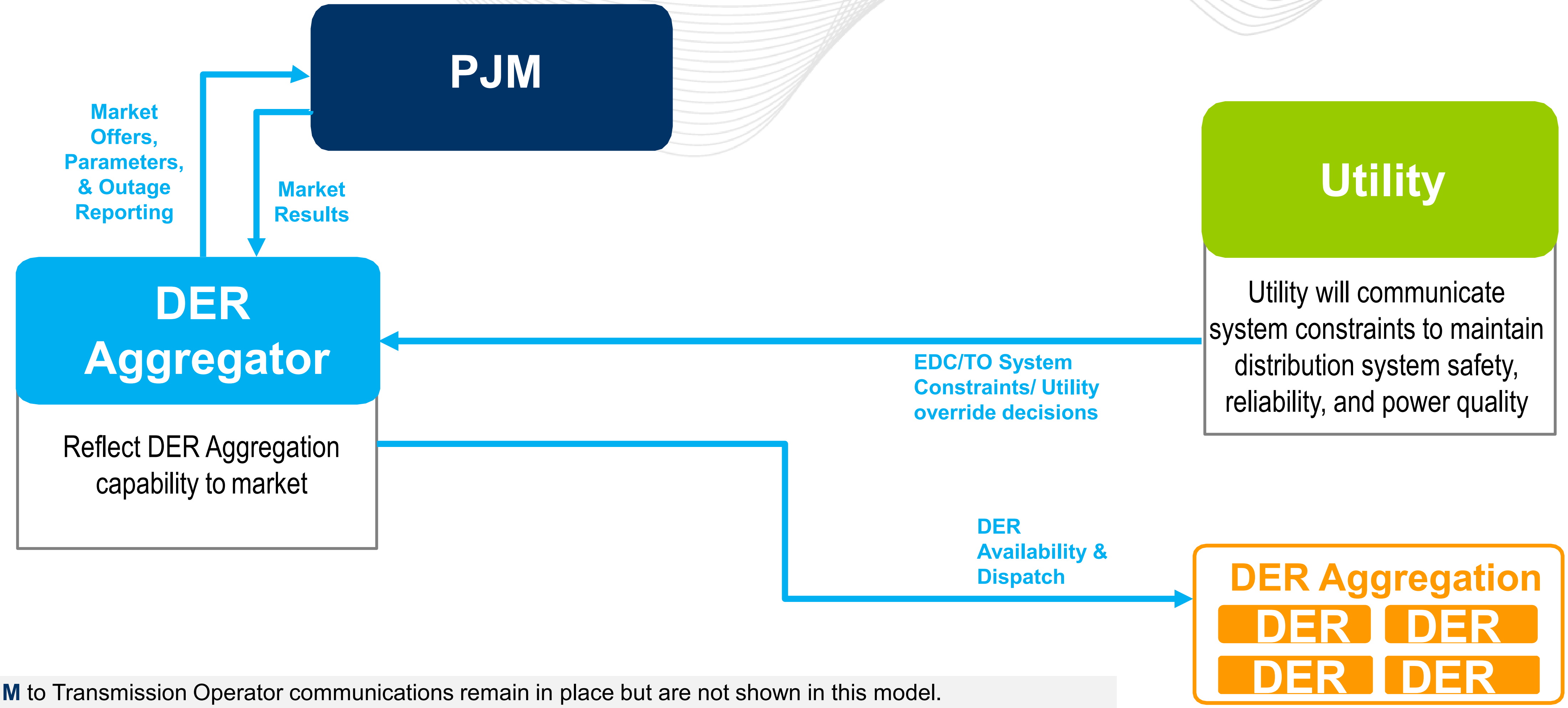
- EDC has sole responsibility for the reliable operation of the distribution system and retains authority to override PJM's market dispatch.

- EDCs should coordinate with the DER Aggregator on planned maintenance and other distribution work that will impact dispatchability of Component DER/DERA **prior to day-ahead** to allow aggregator to accurately reflect DERA capability in the market.
  - The DER Aggregator will be required to update the resource's bid parameters to reflect any altered capability.

- **Real-time** overrides are expected to be rare but may result from unplanned outages, safety, or load beyond forecasted expectations.
  - These should be communicated by the EDC to the DER Aggregator as soon as possible.
  - The aggregator is to follow EDC direction and update their economic parameters accordingly in PJM Markets.

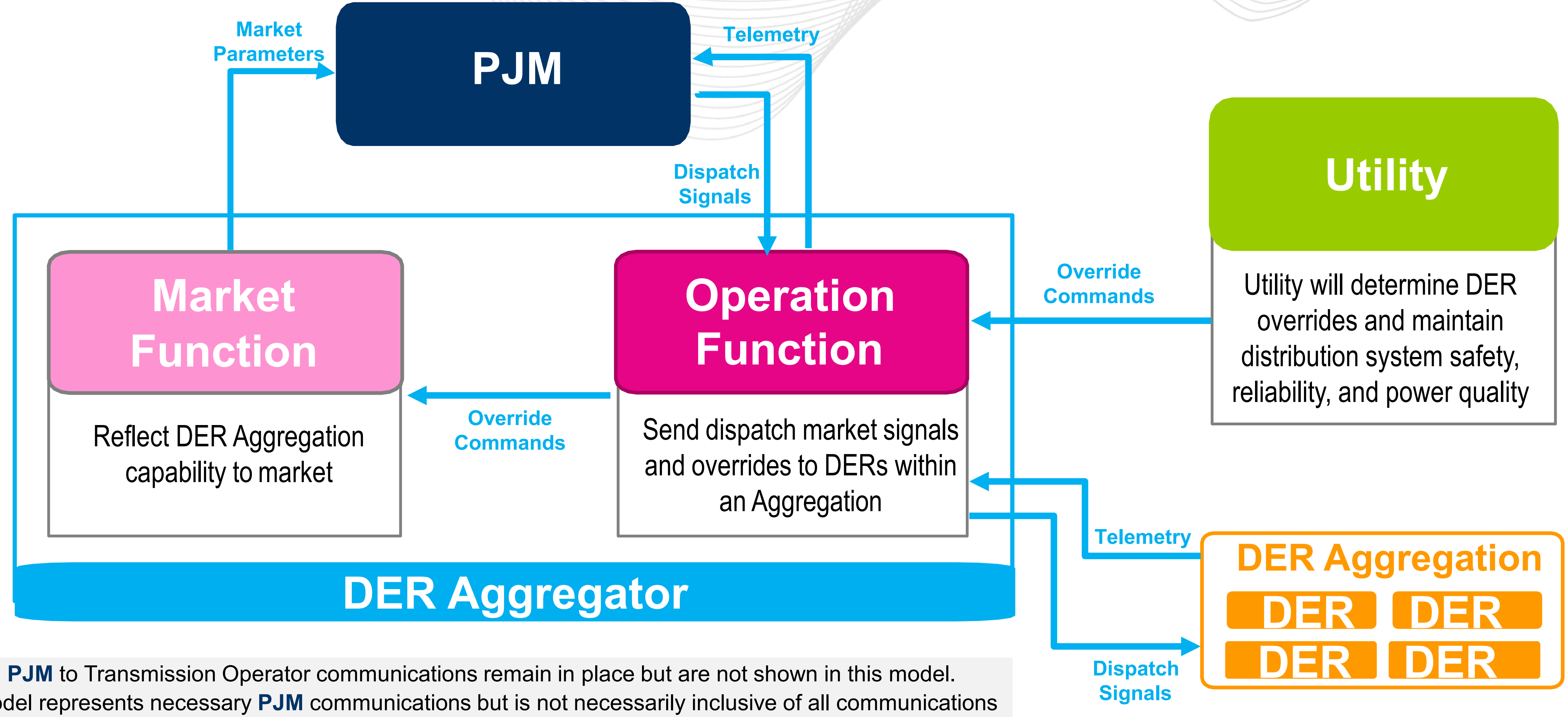
- DERAs are not eligible for LOC or PAI excusals due to EDC override and will be subject to any applicable deviation changes / penalties.

Day-Ahead Market Operational Coordination



- Existing **PJM** to Transmission Operator communications remain in place but are not shown in this model.
- This model represents necessary **PJM** communications but is not necessarily inclusive of all communications required by the utility

Real-Time Market Operational Coordination



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- This model represents necessary **PJM** communications but is not necessarily inclusive of all communications required by the utility

Operations	
Locational Requirements	• Nodal model to align with PJM dispatch and pricing • Primary location node will be identified in PJM system • All DER in a DERA primarily map to same node • Limited multi-nodal option available
Telemetry	• Telemetry will be required at the DER aggregation level • All capacity & ancillary service DERA, and all energy only DERA >=10MW will provide PJM telemetry
Cyber Security	• PJM will implement cyber security at PJM's "first hop" • Additional cyber security needed
Outage Reporting	• Outage reporting will be required for DERAs in capacity market

Locational Requirements

- What do locational requirements define for DER aggregations?
  - Locational requirements define which Component DER can be aggregated into a market resource (DERA) based on their location on the distribution system.
    - Location requirements will define how DERAs are modeled and dispatched for Energy & Ancillary Services.
    - These locational requirements will *not* define Capacity Market participation, Ancillary Service performance evaluations, or Ancillary Services Only aggregations.

Locational Requirements

- What is the locational requirement for DER aggregations?
  - Each Component DER in an aggregation must be at the **same primary electrical location** (i.e., interface with the same primary pricing node), except:
    - in the case of a DER Aggregation that only provides ancillary services and is less than or equal to 5 MW, the Component DER within the aggregation may interface with multiple primary pricing nodes, so long as those nodes are in the same state, service territory of a single EDC, and are in the same Transmission Zone;
    - in the case of a DER Capacity Aggregation Resource, the Component DER linked to the resource may interface with multiple primary pricing nodes, so long as those primary pricing nodes are located within a defined zone or sub-zonal Locational Deliverability Area;
    - the case of the limited multi-nodal option described in subsequent slides.

Locational Requirements

- Why nodal?
  - The nodal approach is the only workable option in the short-term for larger DER Aggregations and for aggregations *regardless* of size at scale.
  - Supply must respond nodally to LMP in order to effectively control constraints.
    - Constraint control without nodally dispatchable resources would not just be inefficient, it could become infeasible from generation alone, ultimately requiring load shed.

Locational Requirements

- The DER model should foster innovation and facilitate entry of small Component DER while experience is gained and the market is able to mature.
- Given the difficulty of aggregating to 100 kW at a single node for very small DERs, especially while the market is immature, PJM will permit **limited multi-nodal** aggregations as outlined below.

Component DER can aggregate across nodes under the following rules:

(1) Only one Component DER, or group of Component DER, may be >100kW at a single node because only one is required to be an “anchor” for smaller DERs.

(2) The total MWs of **all** multi-nodal aggregations in a transmission area must not exceed 167 MW across the RTO.

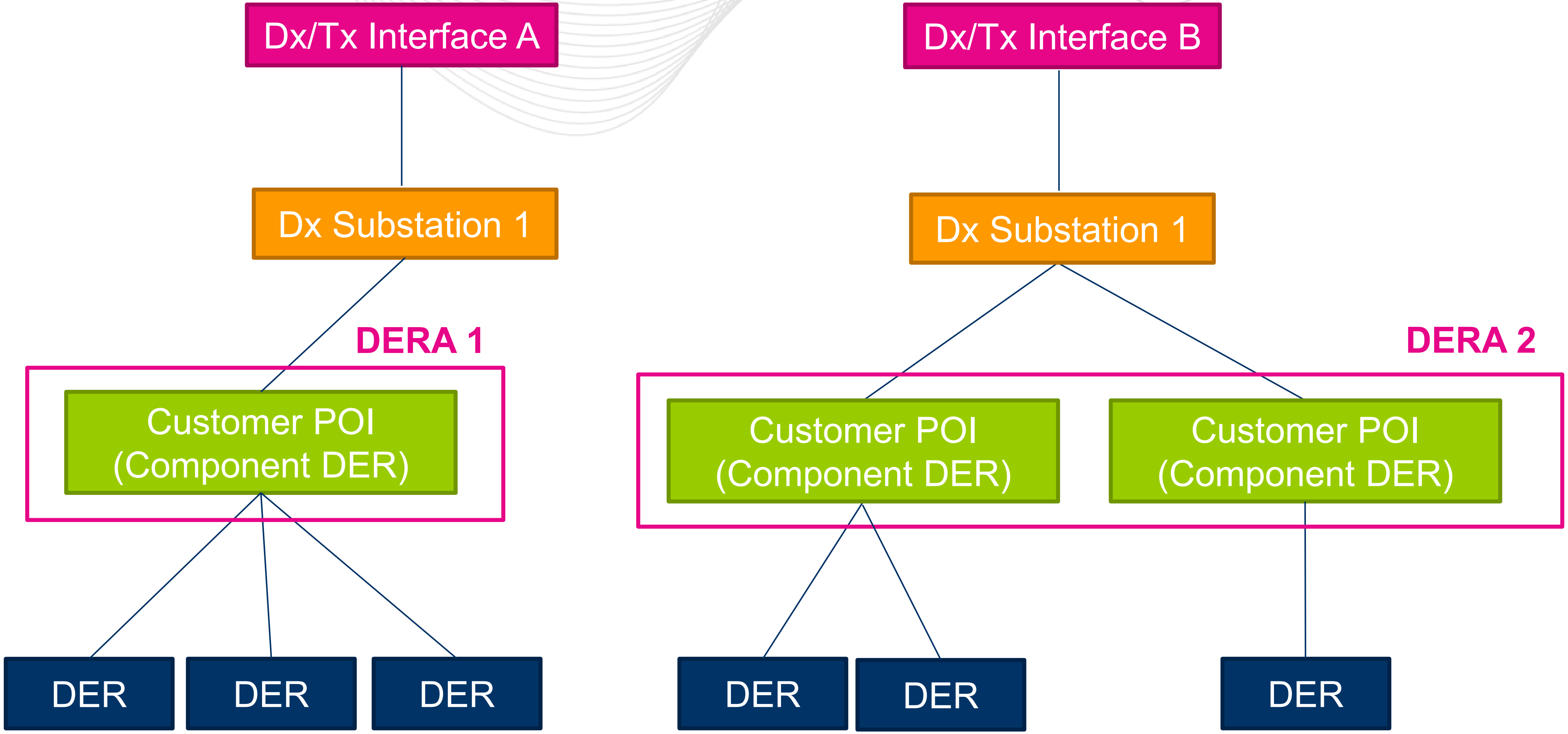
(3) All Component DER in a multi-nodal aggregation must be in the same state, service territory of a single EDC, and in the same Transmission Zone.

PJM will review this cap once the penetration of multi-nodal aggregations reaches at least 90% of the cap.

Locational Requirements

Example 1:

Two DER Aggregation Resources

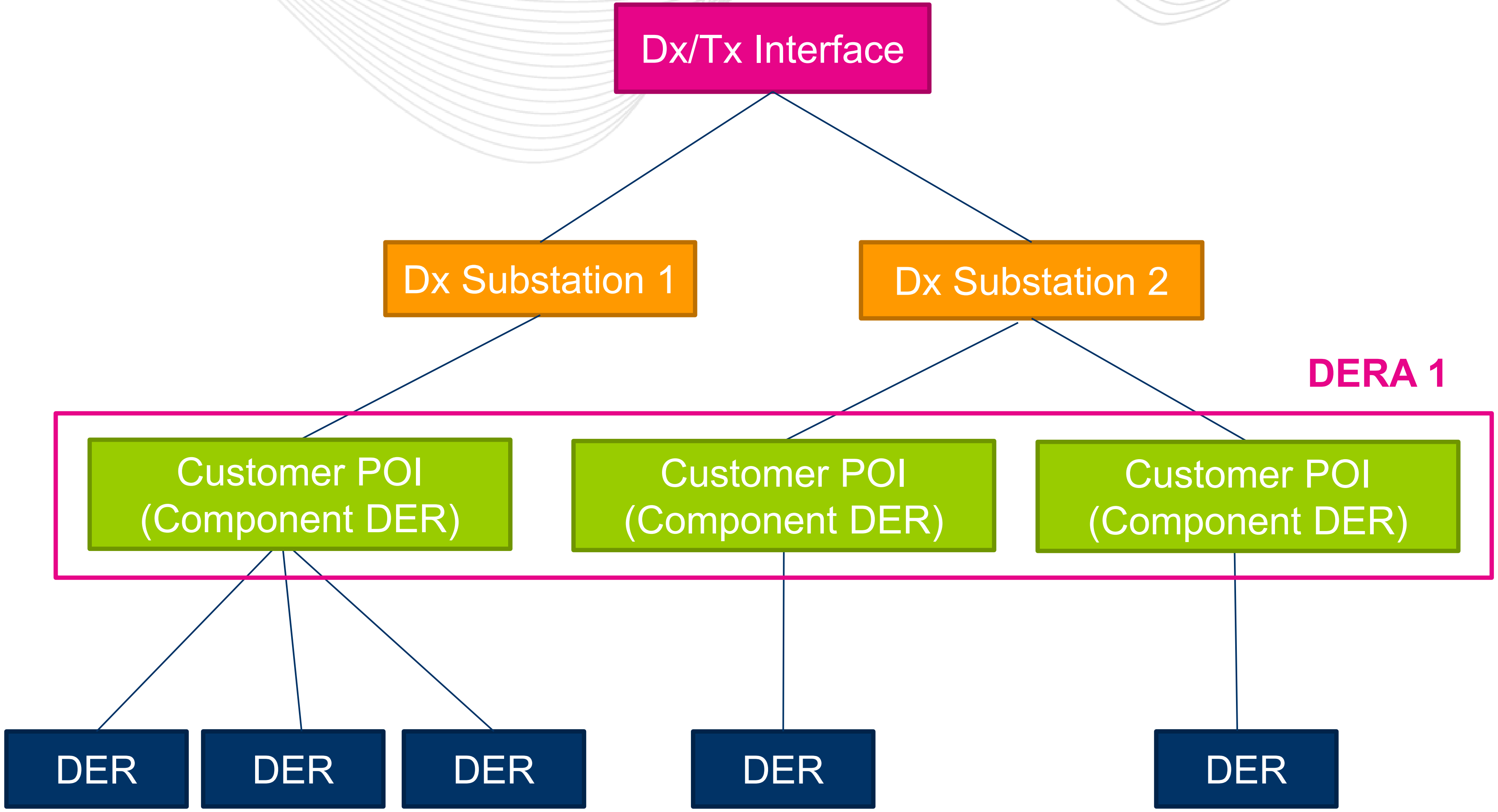


Locational Requirements

Example 2:

One DER Aggregation Resource

- Single location requirement (primary node) evaluated at the Dx/Tx Interface

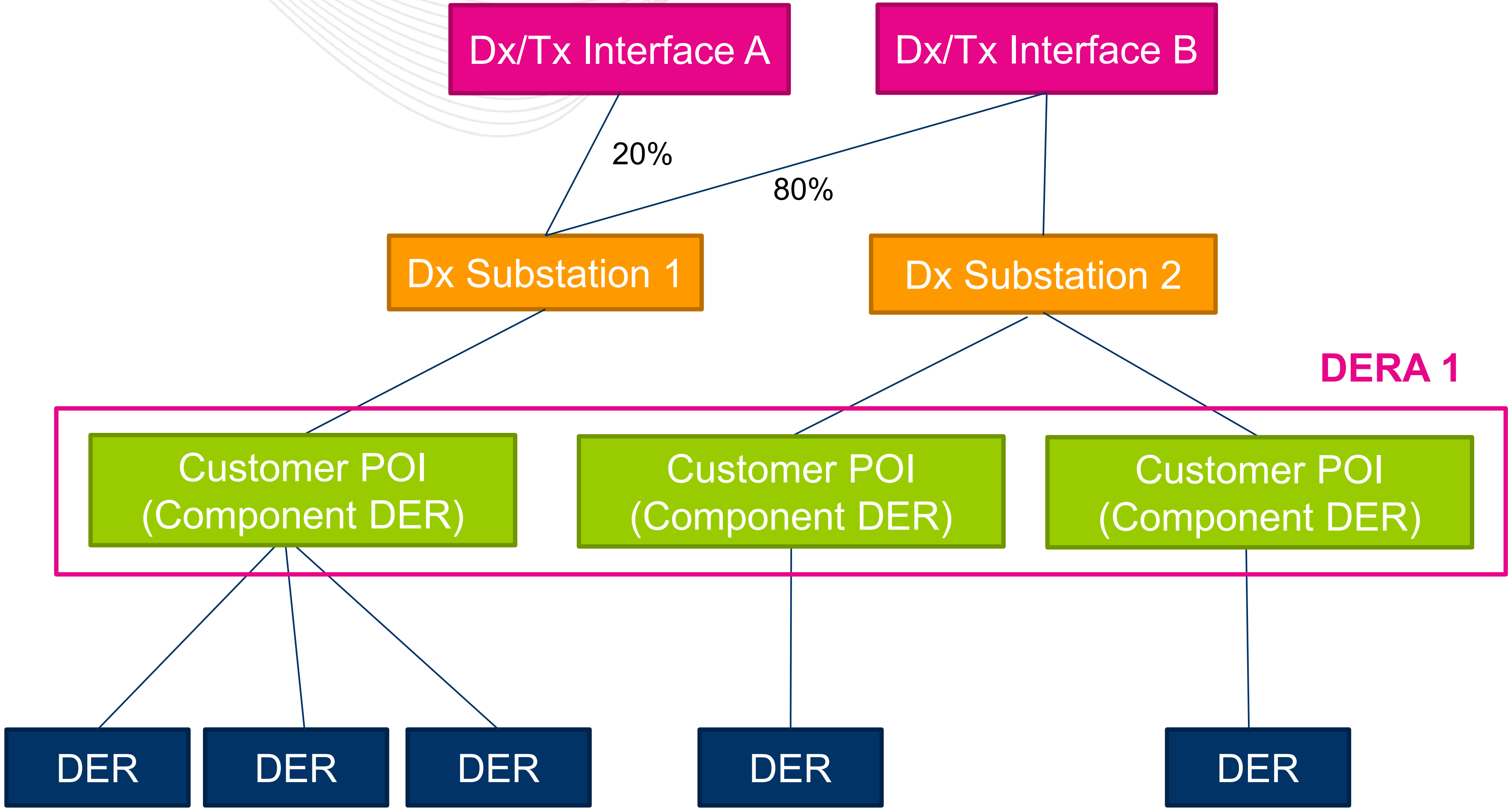


Locational Requirements

Example 3:

One DER Aggregation Resource

- Single location requirement (primary node) evaluated at the Dx/Tx Interface
- Split Nodal Mapping



All the “Factors”

- (inputs/registration) **Capability Factors** (At the DER level)
  - PJM will determine a capability factor, based on the capability indicated for each DERs in a DERA during the registration process. These will not be updated unless the aggregation changes and it is reviewed and approved by PJM/EDC.
- (inputs/registration) **Locational Factors** (At the DER level)
  - This is the mapping that the EDC provides for transmission location(s) during registration process. The values provided will be the PSSE Bus ID(s) and weighting factors, if multiple. This will not be updated unless reviewed and approved by PJM/EDC.
- (operations/markets) **Modeling Impact Factor** (At the DERA level)
  - The factor to be used in pricing/dispatch. It will be calculated from the capability factor and locational factor. There will not be a dynamic update of this value (hourly/daily) but can change over time if DERA changes occur (via registration process).

Registration – Managing Nodal Aggregations

Component DER	Size (MW)	Locational Factor (PSSE Bus ID(S) and weights)	Primary tranx. location	Aggregation Definition	Capability Factor	Modeling Impact Factors
Comp DER1	1	100% Node A	Node A	DERA 1	0.25	Node A - 0.25
Comp DER2	1	100% Node A	Node A	DERA 1	0.25	Node A - 0.25
Comp DER3	1	80% Node A, 20% Node B	Node A	DERA 1	0.25	Node A - 0.20 Node B - 0.05
Comp DER4	1	70% Node A, 30% Node D	Node A	DERA 1	0.25	Node A - 0.175 Node B - 0.075
Comp DER5	1	70% Node B, 30% Node A	Node B	DERA 2	1	Node B - 0.70 Node A - 0.30
Comp DER6	1	100% Node C	Node C	DERA 3	1	Node C - 1.0

Registration – Managing Nodal Aggregations

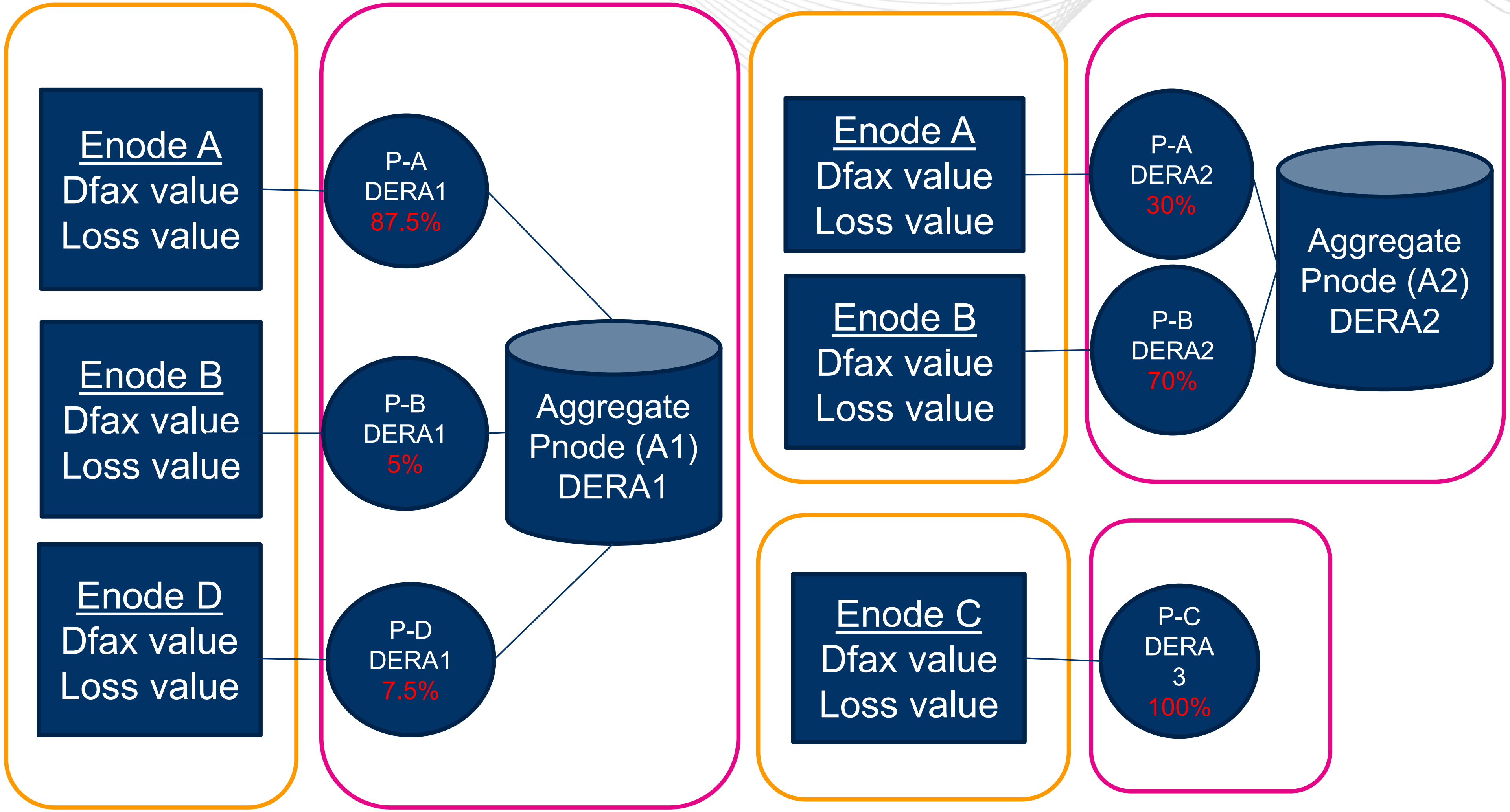
Component DER	Size (MW)	Locational Factor (PSSE Bus ID(S) and weights)	Primary tranx. location	Aggregation Definition	Capability Factor	Modeling Impact Factors
Comp DER1	1	100% Node A	Node A	DERA 1	0.25	Node A - 0.25
Comp DER2	1	100% Node		DERA 1	0.25	Node A - 0.25
Comp DER3	1	80% Node A 20% Node B		DERA 1	0.25	Node A - 0.20 Node B - 0.05
Comp DER4	1	70% Node A, 30% Node D	Node A	DERA 1	0.25	Node A - 0.175 Node B - 0.075
Comp DER5	1	70% Node B 30% Node A		DERA 2	1	Node B - 0.70 Node A - 0.30
Comp DER6	1	100% Node		DERA 3	1	Node C - 1.0

DERA 1
0.875 – Node A
0.050 – Node B
0.075 – Node D

DERA 2
0.70 – Node B
0.30 – Node A

DERA 3
1.0 – Node C

Modeling Impact Factors – Implementation



- DERA locational requirements are single location, or nodal
- All Component DERs in an aggregation must map to 1 primary location
- Dispatch engine model is multi-nodal pricing (similar to combined cycles) when DERA is mapped to more than 1 node for proper operational modeling

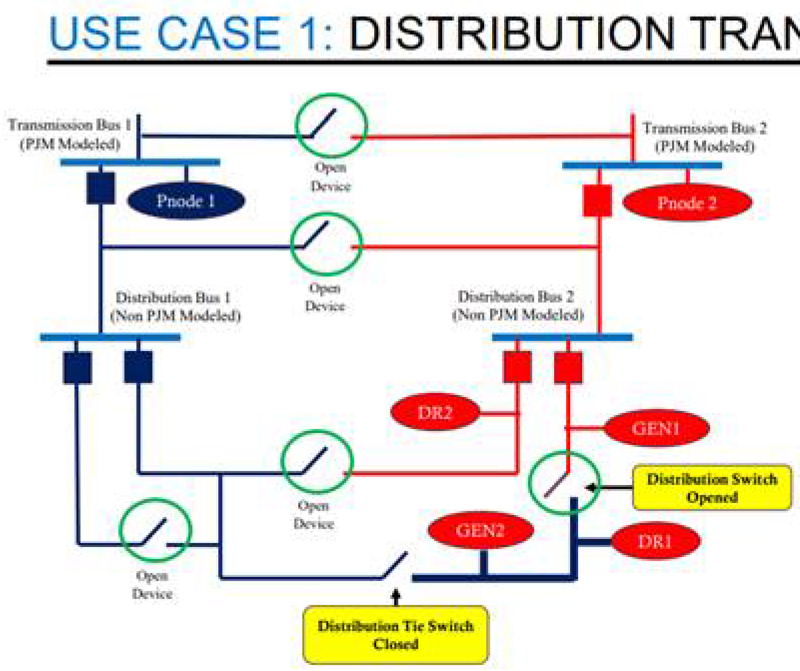
Roles and Responsibilities

Data	Provided By?	Verified By?	When?
Capability/Size (MW)	Aggregator	Utility	Registration
Capability Factor	PJM	PJM	Registration
Locational Factors	Utility	PJM/Utility	Registration
Primary Location	Utility/PJM	Utility	Registration
Modeling Impact Factors	PJM	PJM	After Registration

Changes to Component DER Electrical Location

- Locational modeling can be updated but is not intended to be dynamic on an hourly/daily basis
  - Modeling will be done on “normal” distribution configurations
    - Capturing dynamic updates in real-time for distribution system is unattainable
  - This will not impact DERA market participation and small inaccuracies may exist based on distribution switching
  - Long term changes will be addressed with a modeling update
    - PJM will update mapping when provided by the utility
    - No less than a yearly review on locational mapping accuracy

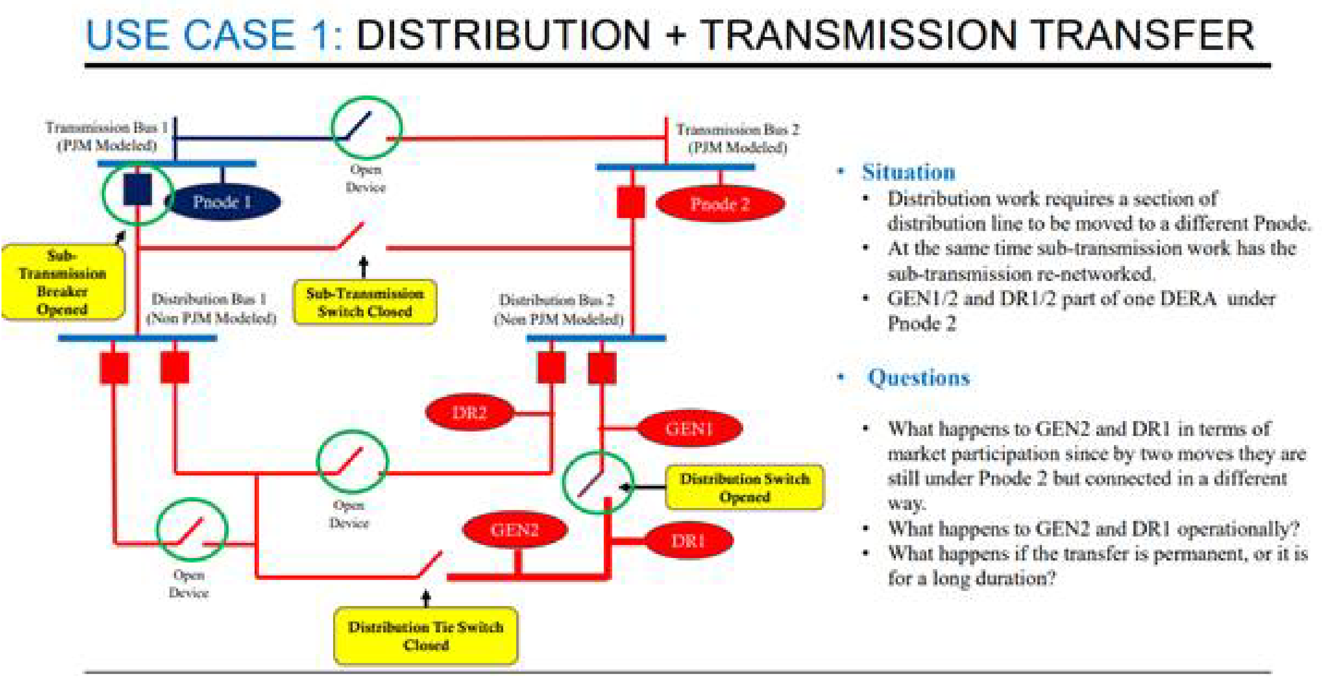
Changes to Component DER Electrical Location



- **Situation**
  - Distribution work requires a section of distribution line to be moved to a different Pnode
  - GEN1/2 and DR1/2 part of one DERA under Pnode 2
- **Questions**
  - What happens to GEN2 and DR1 in terms of market participation?
  - What happens to GEN2 and DR1 operationally?
  - What happens if the transfer is permanent or for a long duration?

- **Market Participation:** DERA would still be able to participate at Pnode 2, even though flows would go over Pnode 1 and 2.
- **Operations:** DERA still able to participate in PJM. If EDC in unable to allow these resources to safely operate due to switching, they should perform overrides.
- **What happens if the transfer is permanent or for a long duration?** Modeling will be updated to reflect new “normal” distribution flows. This may result is splitting the DERA if locational requirements are no longer met.

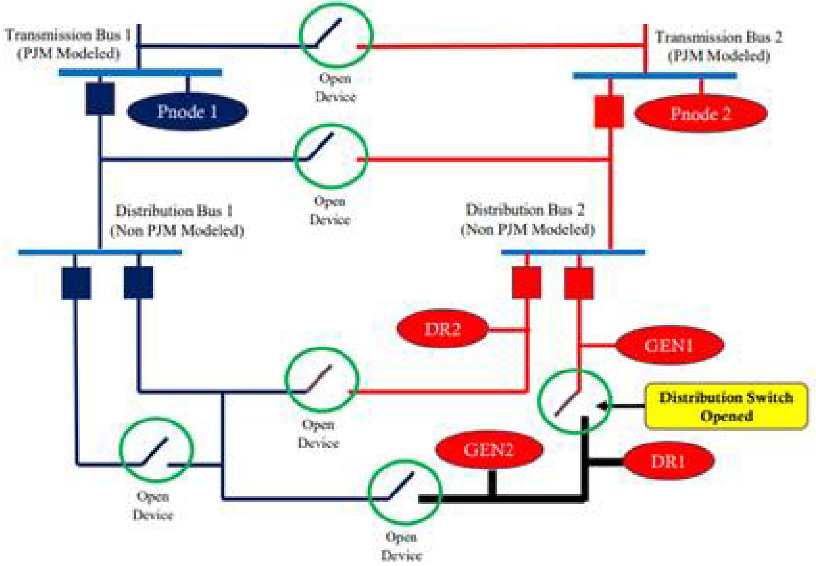
Changes to Component DER Electrical Location



- **Market Participation:** DERA would still be able to participate at Pnode 2.
- **Operations:** DERA still able to participate in PJM. If utility has short-term operational reliability concerns, they should perform overrides. Long-term reliability concerns should be communicated to the aggregator and could result in the withdrawal of the Component DER from the wholesale market.
- **What happens if the transfer is permanent or for a long duration?** No changes as it still maps to same Pnode on PJM system.

Changes to Component DER Electrical Location

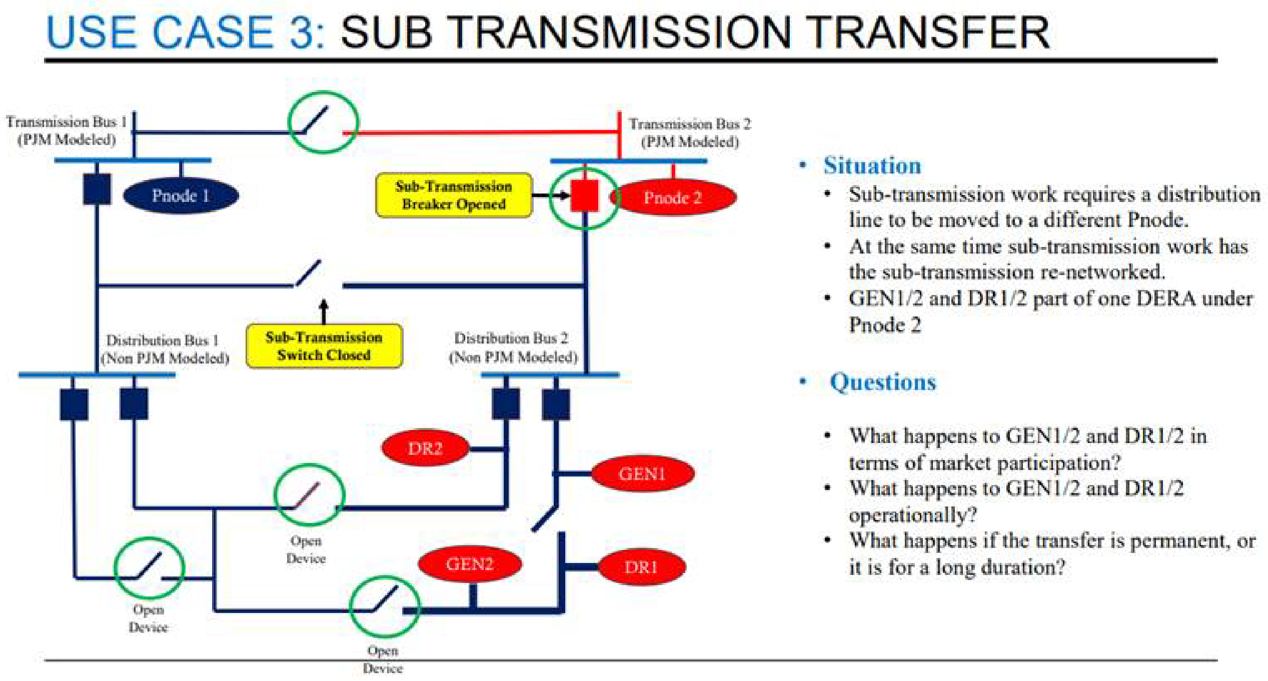
USE CASE 2: DISTRIBUTION OUTAGE



- **Situation**
  - Distribution experiences an outage on a line segment.
  - GEN1/2 and DR1/2 part of one DERA under Pnode 2
  - GEN2 / DR1 either de-energize or remain on if they are tied to an ATS.
- **Comment**
  - It is assumed that that GEN2/DR1 will not participate in the market during the outage.
- **Questions**
  - What operational parameters will energy storage / generation and storage assets be permitted during outage if the customer has an automatic transfer switch (aka outage backup)

- **Operations:** In case of an outage, the de-energized part of a DERA result in decreased capability for wholesale participation.
- **Market Participation:** The DER Aggregator would reflect this in the market by updating the relevant parameters.
- Resource would not be able to provide back up power and be settled by PJM.

Changes to Component DER Electrical Location



- **Market Participation:** DERA would still be able to participate at Pnode 2, even though flows would go over Pnode 1 (assuming short term switching).

- **Operations:** DERA still able to participate in PJM. If EDC in unable to allow these resources to safely operate due to switching, they should preform overrides.

- **What happens if the transfer is permanent or for a long duration?** Modeling will be updated to reflect new “normal” distribution flows.

- What is telemetry?
  - Telemetry is data that is being provided to PJM in real-time.
  - Telemetry is transmitted through internet-based SCADA (Jetstream) or ICCP
- The DER Aggregator will send the following telemetry values for the DER Aggregation Resource:
  - MW value (MVAR data not required)
  - Data quality flag for telemetry value
  - DERAs with ESRs will need to provide SOC telemetry
  - Meteorological (irradiance and back panel temp) data and MW for Solar >= 3MW (by location/DER) at 5 min intervals
  - Aggregators may be expected to have individual DER telemetry data available (for EDC requests and/or audit purposes)

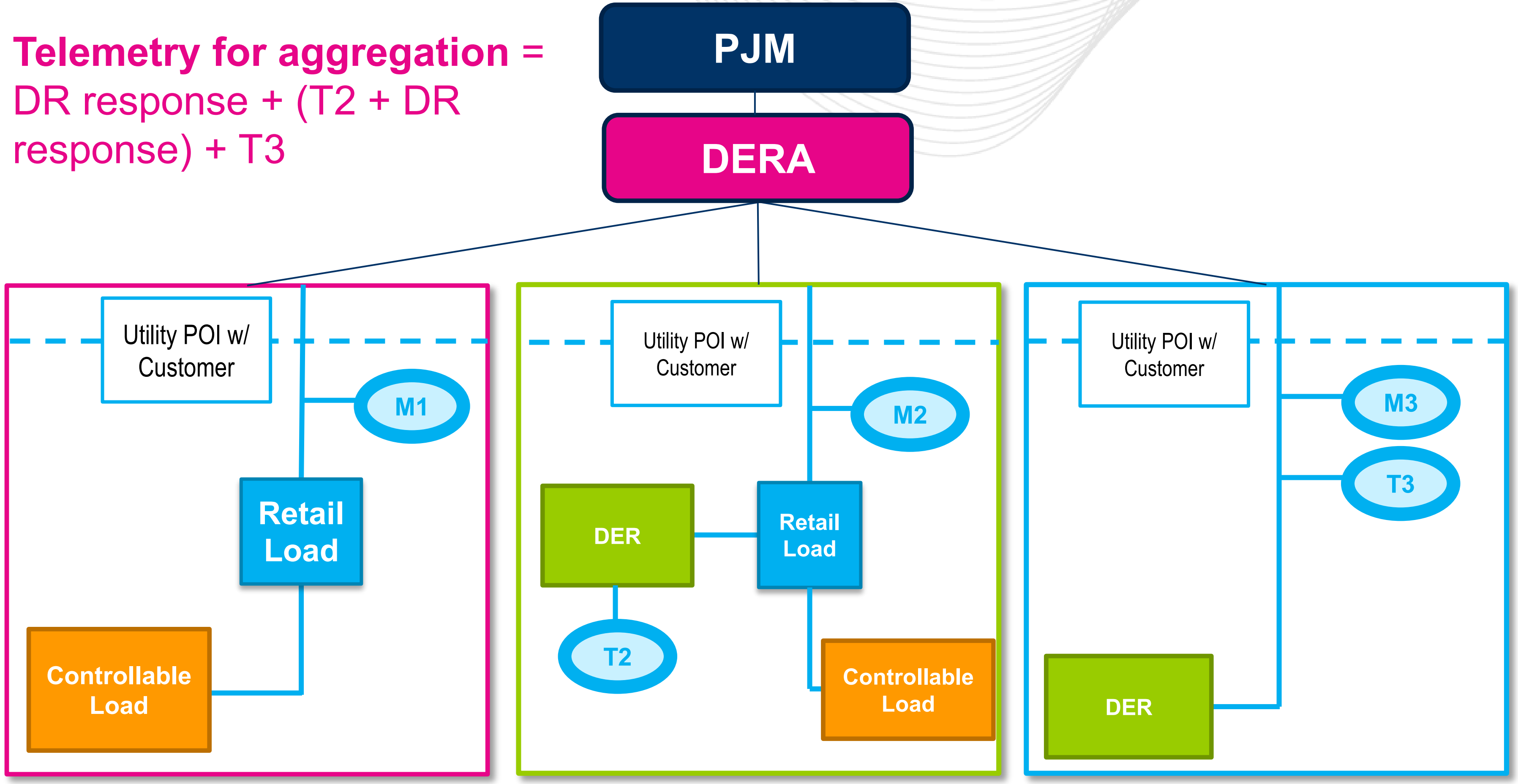
Market		Telemetry	Accuracy
Capacity		1 minute data	+/- 2%
Energy Only	<10 MW	no real-time telemetry required	+/- 2%
	>=10 MW	1 minute data	+/- 2%
Regulation		10 second data	+/- 2%
Reserves		1 minute data	+/- 2%

Justification:

- SE runs every minute
- SCED runs every 5 minutes
- Need to get up-to-date data into dispatch
- Tool for settlements, 5 minute settlements, PAIs and reserve event performance

Telemetry Example

Telemetry for aggregation = DR response + (T2 + DR response) + T3

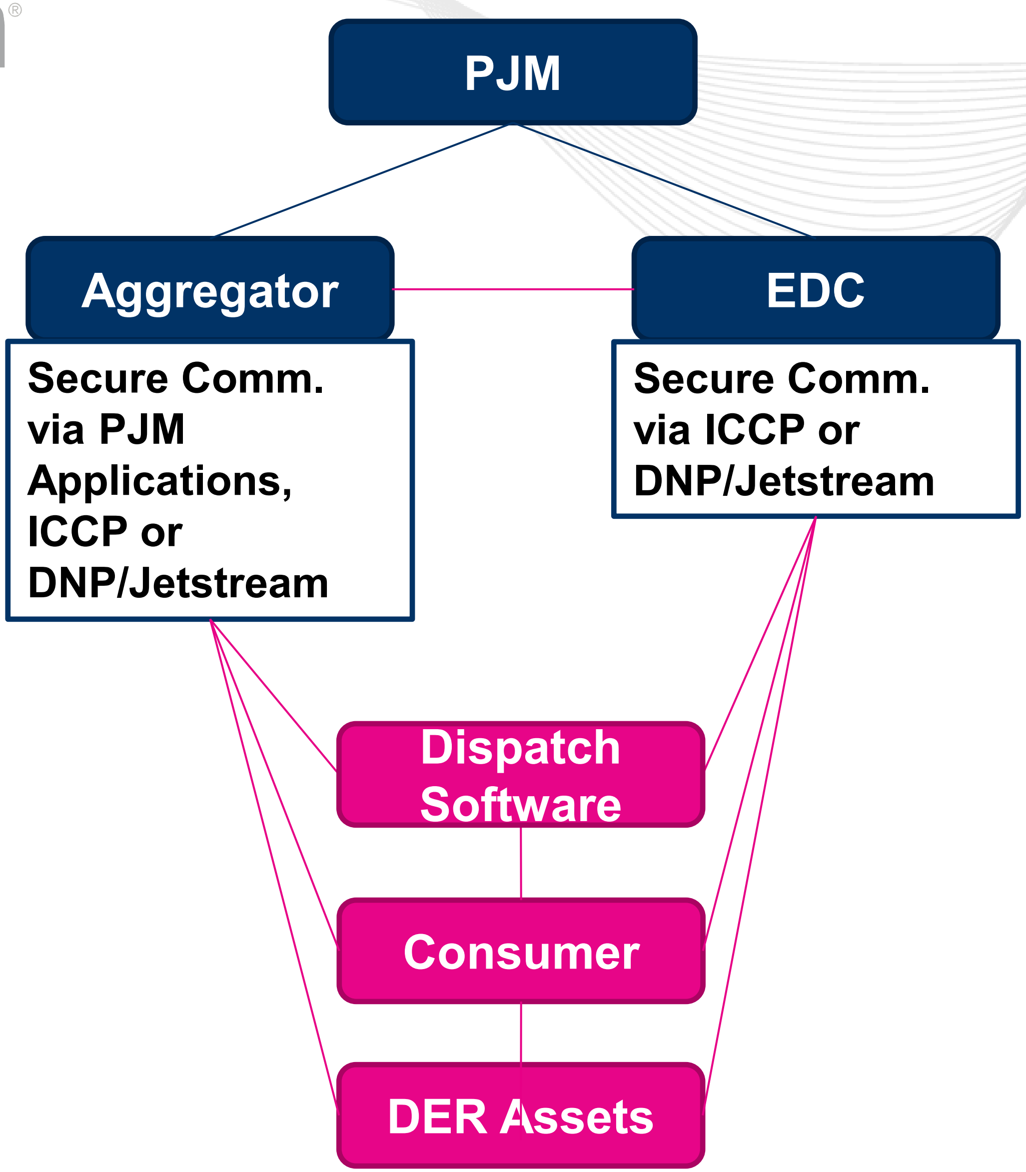


Telemetry for the DER Aggregation level can be an accumulation of individual DER telemetry.

Controllable load does not need to be directly metered.

Mass market aggregation can use sampling analysis to provide telemetry to PJM.

Cyber Security



- Blue lines = PJM defined cyber security requirements
- Pink lines = Utility defined cyber security requirements

Outage Reporting

- Outages must be reported for:
  - All DER Aggregation Resources with a capacity commitment
  - All energy-only DER Aggregation Resources >=10 MWs
- Outage rules by DER type:
  - *Injecting DERs:* Planned and maintenance outages should be reported for equipment issues based on existing rules (e.g., an outage is not required for lack of wind, sun, battery SOC etc.)
  - *Load response:* Planned outages not permitted; maintenance outages should follow existing rules for demand response
    - Only permitted between October and April
    - Maintenance or repair at facility on end use device or generator that will be used to reduce load (may be between 1 and 30 days)
    - CSP maintenance to dispatch system (limited to one day which must be a Saturday or Sunday, up to twice per quarter)

Settlements	
Metering Configuration & Requirements	• Data submissions for settlements will follow existing PJM PowerMeter and InSchedule requirements
Settlement Requirements	• Uphold Order 745 for DR Settlements
Double Counting Services	• Double counting will not be permitted participating in PJM Markets • Determination of double counting due to retail activity will be determined by the EDC
Use Case Development	• List of use cases to test proposal requirements

Settlement

- Revenue quality meter data is required to be submitted to PJM at least at an hourly granularity in accordance with Manual 28, sections 1A and 3.
- Meter data must be submitted one business day after the operating day.
- Settlement will occur at the DER Aggregation Resource level in PJM Markets; however, meter data will need to be submitted at the individual Component DER level.
  - This will allow PJM the ability to properly settle MWh for different types of DERs.

Settlements – Day-ahead

- DERAs which clear in the day-ahead market will be settled at the applicable day-ahead LMP.
- For any demand response resources in a DERA:
  - Demand Response MWs will be settled following demand response methodologies, but on the 1 business day deadline common to all DER resources.
  - PJM will settle Demand Response resources participating in a DERA (homogeneous or heterogeneous) consistent with Order 745 requirements.
- If a Demand Response clears day-ahead as part of DERA, PJM will adjust the day-ahead load of the LSE associated with the resource (i.e., apply a negative load bid in day-ahead to that LSE).
  - This negative load bid will be referred to as the negative dec bid throughout this presentation.

- DERAs which clear day-ahead will be settled for any deviations from day-ahead commitments in the balancing spot market.
  - When dispatched in real-time, the day-ahead commitment will be zero.
- Any demand response in a DERA will have reductions settled as real-time load response.
- Because DERAs will be modeled as no-commitment units, any DERA that clear day-ahead or are dispatched by PJM in real-time will not be eligible to receive Operating Reserve Make-whole Credits, unless they are manually dispatched by PJM.

Relevant FERC Orders & PJM Filings

9/17/2020	FERC Order 2222
3/18/2021	FERC Order 2222-A
6/17/2021	FERC Order 2222-B
2/1/2022	PJM's First Compliance Filing
3/1/2023	FERC Order on PJM's 2/1/2022 Compliance Filing
6/14/2023	PJM's Compliance Filing on Capacity Market Mitigation Request
9/1/2023	PJM's Compliance Filing in response to 3/1/2023 FERC Order
11/13/2023	FERC Order on PJM's 6/14/2023 Compliance Filing
7/25/2024	FERC Order on PJM 9/1/2023 Compliance Filing
10/23/2024	PJM's Compliance Filing in response to 7/25/2024 FERC Order
5/1/2025	FERC Order on PJM 10/23/2024 Compliance Filing

Relevant Tariff/OA & RAA Sections

Governing Doc	Section	Effective Date
OATT/OA	Definitions A-B / Definitions A-B	Feb 1, 2028
OATT/OA	Definitions C-D / Definitions C-D	July 1, 2025
OATT/OA	Definitions E-F / Definitions E-F	Feb 1, 2028
OATT	Attachment DD, Section 5.14 (Clearing Prices and Charges)	July 1, 2025
OATT	Attachment DD, Section 6.6A (Offer Requirement for Capacity Performance Resources)	Feb 1, 2028
OATT	Attachment DD, Section 10A (Charges for Non-Performance and Credits for Performance)	Feb 1, 2028
OATT	Attachment DD, Section 11B (DER Capacity Aggregation Resource Test Failure Charge)	Feb 1, 2028

Relevant Tariff/OA & RAA Sections

Governing Doc	Section	Effective Date
OATT/OA	Attachment K, Appendix, Section 1.2 / Schedule 1, Section 1.2 (Cost-based Offers)	Feb 1, 2028
OATT/OA	Attachment K, Appendix, Section 1.4B / Schedule 1, Section 1.4B (DER Aggregator Participation Model)	Partially effective July 1, 2025
OATT/OA	Attachment K, Appendix, Section 1.10.1A / Schedule 1, Section 1.10.1A (Scheduling)	Feb 1, 2028
OATT/OA	Attachment K, Appendix, Section 3.3A.5 / Schedule 1, section 3.3A.5 (Economic Load Response Participants)	Feb 1, 2028
OATT/OA	Attachment K, Appendix, Section 6.4.2 / Schedule 1, 6.4.2 (Offer Price Caps)	Feb 1, 2028
OATT	Attachment N-4 (DERA Pro-Forma)	Dec 28, 2025
OATT	Attachment Q (Credit Risk Management Policy)	July 1, 2025

Relevant Tariff/OA & RAA Sections

Governing Doc	Section	Effective Date
RAA	Article 1. Definitions	Dec 28, 2025
RAA	Schedule 6.2	July 1, 2025
RAA	Schedule 8.1.G (Capacity Resource Performance)	Dec 28, 2025
RAA	Schedule 9.2 (Effective Load Carrying Capability Analysis)	Dec 28, 2025

FERC Order 2222 Team:
Order2222_DER@pjm.com

DER Aggregator Participation Model

FERC Order 2222 Team

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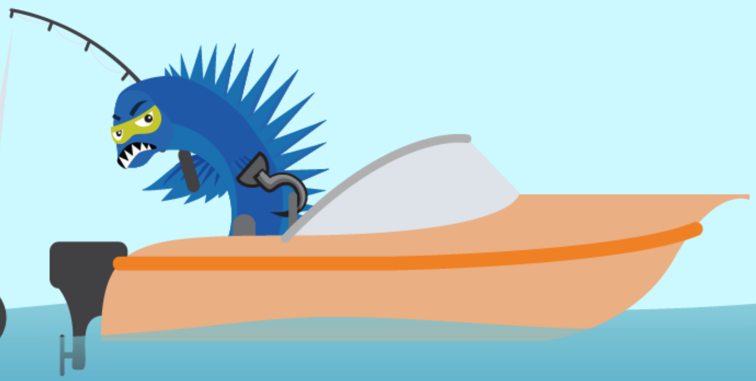
@pjm.com

PROTECT THE POWER GRID

THINK BEFORE YOU CLICK!

pjm



BE ALERT TO MALICIOUS PHISHING EMAILS

Report suspicious email activity to PJM.

Call (610) 666-2244 or email it_ops_ctr_shift@pjm.com