DER Integration into Markets and Operations

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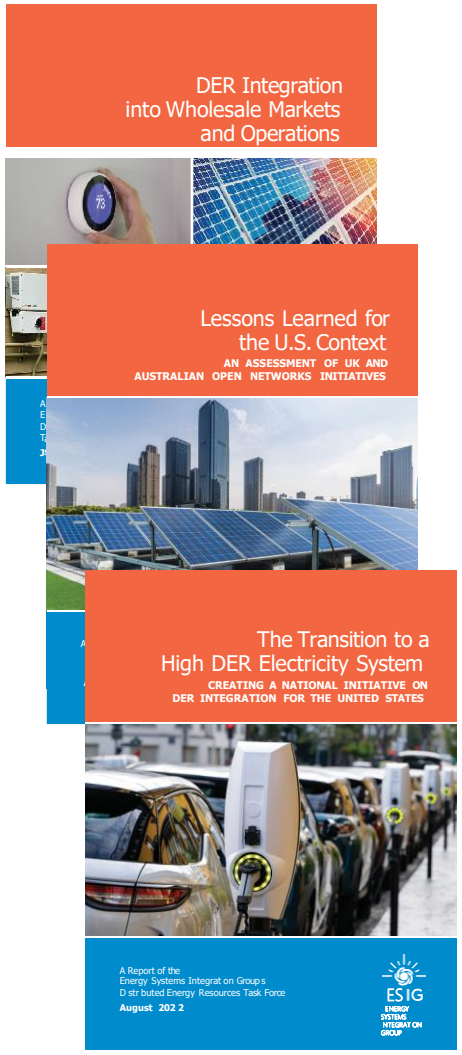
ESIG three-part series on DER integration



DER Integration into wholesale markets and operations.
Examines the changes in regulation, market rules, planning, and operating practices needed to better integrate DERs into U.S. wholesale markets and operations, addressing both near term opportunities and long-term needs.

Lessons Learned for the U.S. Context: An Assessment of UK and Australian Open Networks Initiatives. Reviews the UK and AU open networks initiatives and highlights elements that could be useful to incorporate in a US initiative on DER integration and characteristics from each initiative that should be avoided.

The Transition to a High-DER Electricity System: Creating A National Initiative for DER Integration for the United States. Leveraging the first two reports and inputs from the task force, this report clarifies the need, value and design of a potential US national initiative.

https://www.esig.energy/der-integration-series/

Key areas and actions for regulatory commissions and distribution utilities to support FERC Order 2222 compliance

	Actions Needed by Commissions	Actions Needed by Distribution Utilities
Interconnection procedures	Ensure that interconnection procedures are transparent, are fair, and conform to predictable costs and time frames	Develop new or enhance existing DER interconnection procedures to establish DER performance parameters (e.g., maximum injection limits) and utilities' ability to curtail DER power injections for reliability purposes
DER aggregation review	Ensure that utility aggregation review is timely, fair, and flexible, avoiding the need for new interconnection studies	Develop transparent procedures for review within 60 days of an aggregator proposing a DER aggregation
Outage communication	Ensure that distribution utility outage communication is timely and fair, allowing DER providers to manage non-performance risks in the wholesale market	Develop new processes and capabilities for communicating distribution outages or constraints to DER aggregators
Utility overrides	Ensure that distribution utility overrides are transparent and non-discriminatory	Develop transparent, non-discriminatory procedures for overriding ISO/RTO scheduling and dispatch of DERs that align with expectations set within the aggregation review process

Focus in on market operations

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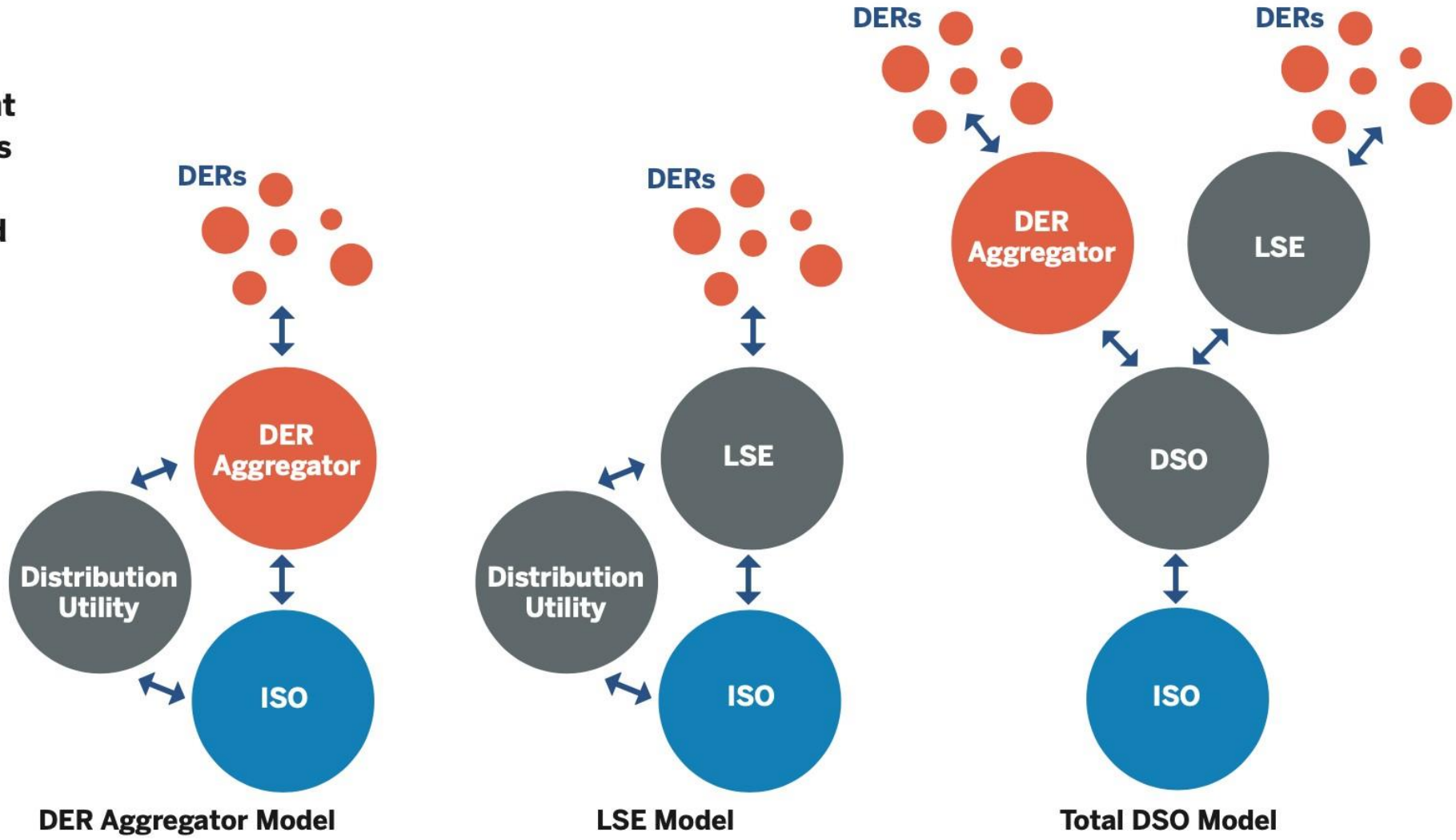
We examined three structural participation models

Structural participation models describe different approaches for how DERs participate in wholesale markets; they vary based on the nature of the interactions among the ISO, distribution utility, and DER aggregator.

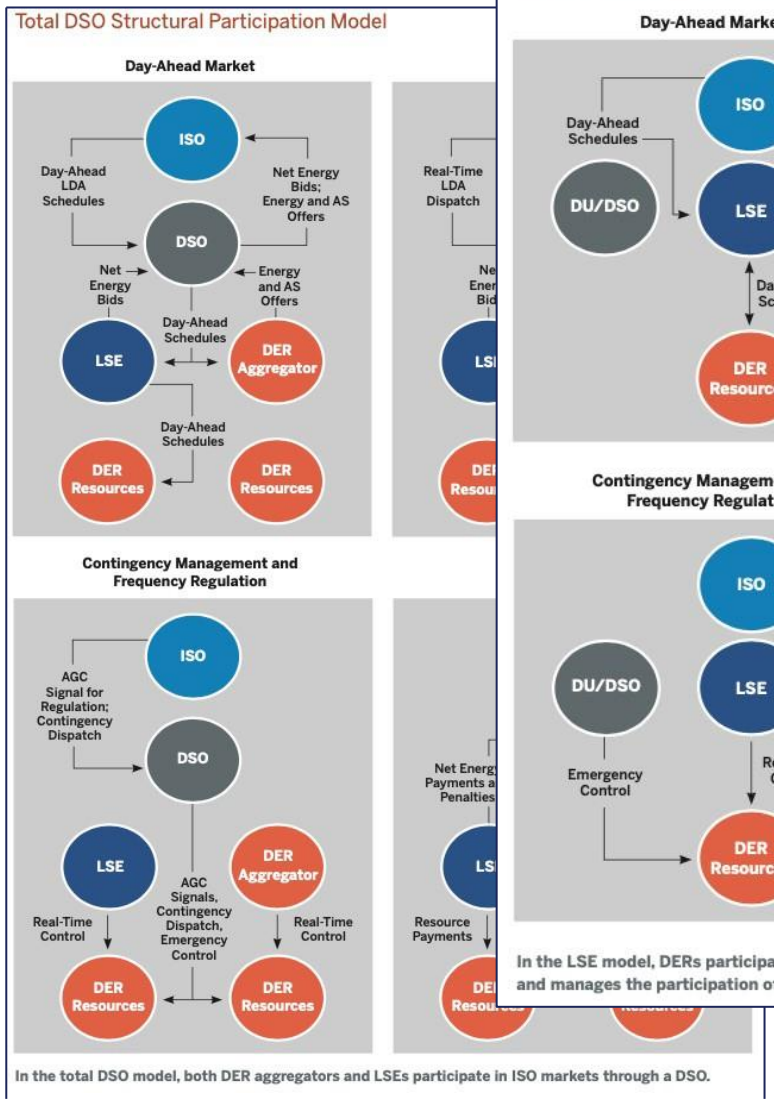


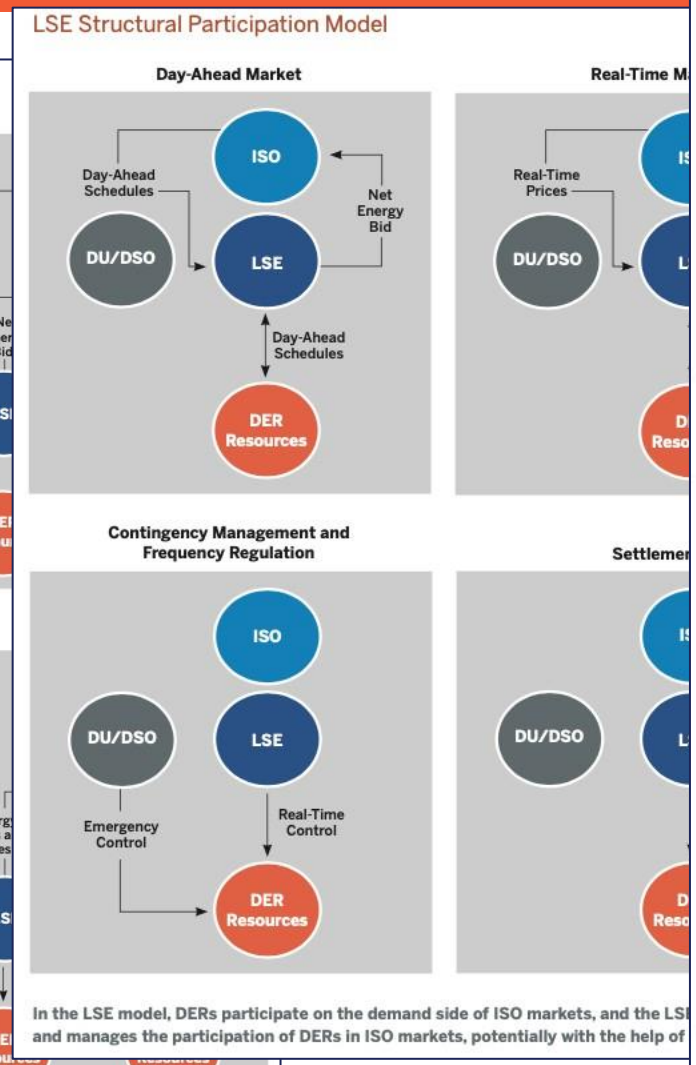
DER Aggregator Model

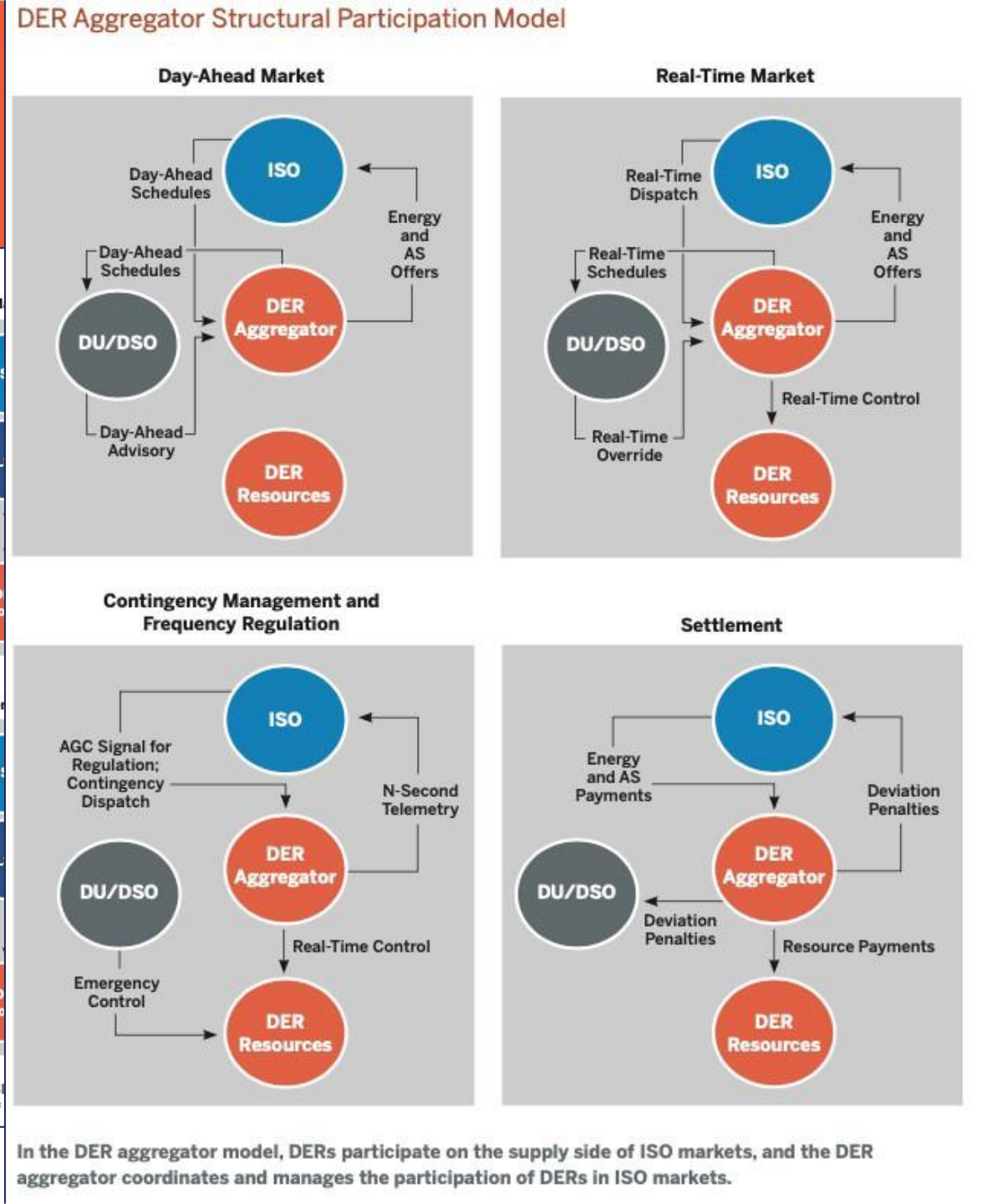
LSE Model

Total DSO Model

We examined market operations across the different models







Market Processes and Operator Functions

Pre-operations and Planning

Market Process	Operator Function	
	DU/DSO	ISO
Registration of market participants and resources	Register market participants (DER providers) and participating resources (DERs or DERAs)	Register market participants (DER providers) and participating resources (DERs or DERAs)
Distribution planning	Plan investments in distribution infrastructure and non-wires technologies	Provide DU/DSO with timely information on planned transmission expansion
Transmission planning	Provide ISO with i and DER forecasti	
DER interconnection	Set interconnecti screens and studi	
Resource verification	Review DERA; rev communications	
Resource adequacy	Verify deliverabilit	
Maintenance scheduling	Manage and repo equipment outag	

Market and System Operations

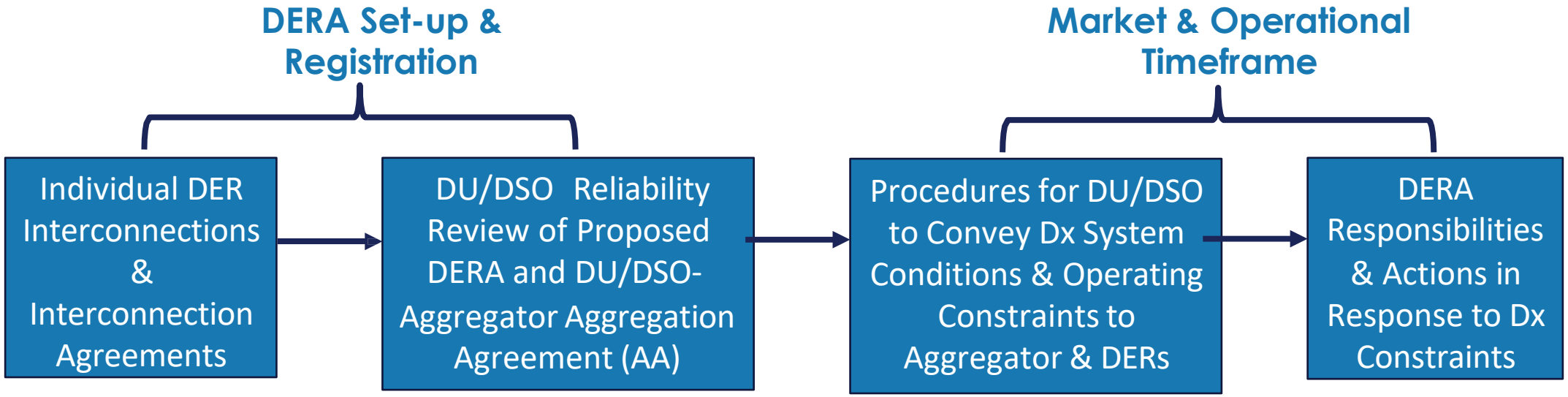
Market Process	Operator Function	
	DU/DSO	ISO
Day-ahead market	Schedule DERs that provide distribution grid services to the DU/DSO	Perform scheduling and unit commitment
Real-time market	Dispatch DERs that provide distribution grid services to the DU/DSO; ensure distribution system security and, in some models, perform economic dispatch	Perform security-constrained economic dispatch
Contingency management	Manage outages and provide emergency control	Manage outages and provide contingency dispatch
Frequency balancing		
Voltage regulation		

Market Settlement

Market Process	Operator Function	
	DU/DSO	ISO
Market settlement	Assess penalties for DERs' or DERAs' non-compliance with override instructions; perform market settlement in some models	Settle day-ahead energy, real-time energy, and ancillary service markets; assess imbalance penalties
Network tariffs and settlement	Settle non-wires resources; distribution tariffs; and tariffs for generation, storage, and demand response	Settle transmission tariffs

Operational Coordination Architecture

- Provide a framework for the distribution utility (DU) or distribution system operator (DSO) to manage reliability impacts to distribution resulting from aggregations of DERs (DERA) participation in the ISO market under changing distribution system conditions.
- Satisfy FERC 2222 requirements for DU/DSO to implement "transparent, non-discriminatory" procedures for over-riding ISO dispatches (para 310).
- Minimize real-time transaction complexity via effective Interconnection Agreement and Aggregation Agreement provisions



In the future, these agreements could include flexible interconnection (dynamic curtailment)

See example

Transparent, Non-Discriminatory Provisions for DU/DSO Curtailment of DERA Dispatch

- These procedures would probably live in a DU/DSO tariff, with references in the Interconnection Agreement and Aggregator Agreement.
- Transparency requires clear specification of the causes of curtailment, compliance requirements, penalties, etc.
- Non-discriminatory requires fair allocation of limited distribution capacity between multiple DERAs that may use some of the same capacity

DERA Curtailment Options

Simple Approaches

- Full curtailment of all net injecting DERs on a circuit in abnormal configuration
- Pro rata curtailment based on installed capacity
- "First-in-last-curtailed" (e.g., based on commissioning date)

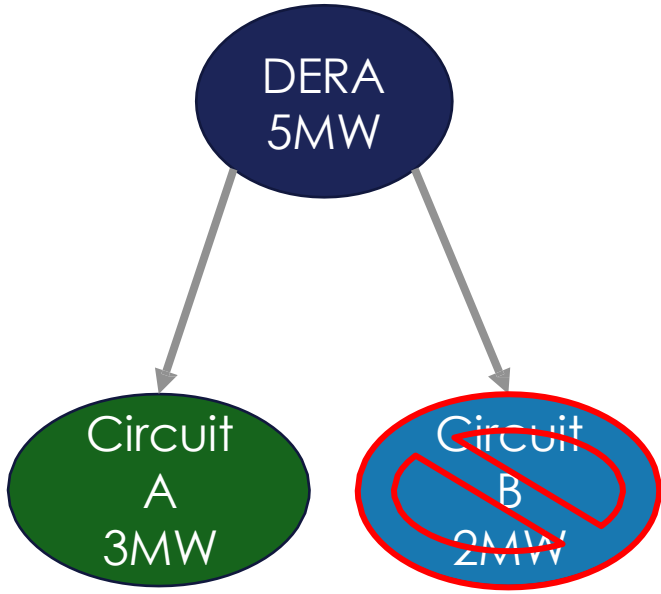
More Complex Approaches

- Physical rights for non-firm (flexible) access to the dist. system are curtailed first
- Economic curtailment
- Economic dispatch of a distribution-level energy market operated by the DU/DSO

Example: Day-to-Day ISO Market and Operational Coordination

DERA in CAISO with 5 MW capacity comprised of individual DERs over two distribution circuits within a single T-D interface. Circuit A hosts 3 MW and circuit B hosts 2 MW. At 9 am Monday the DU/DSO informs the Agg of a problem that has taken out distribution circuit B that will continue for the next 24 hours.

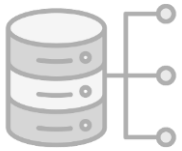
1. The Agg immediately submits an outage/derate card to CAISO indicating DERA capacity reduction from 5 MW to 3 MW for HE10 Monday through HE09 Tuesday
2. The Agg structures its DA market offers for the DERA for Tues to reflect maximum 3 MW for HE01-09 and maximum 5 MW for HE10-24 (based on the expected duration of the circuit B outage)
3. The Agg structures its RT market offers for Monday HE12-24 based on maximum 3 MW capacity; this may involve buying back portions of the DERA's DA schedules (which cleared in Sunday's DAM) for hours where they exceed 3 MWh.
4. The CAISO does not receive new RT offers for 5-minute intervals from 0910 until 1100, but the market optimization knows from the outage/derate card that the DERA's maximum output is 3 MW, so it will not dispatch the DERA for more than 3 MW capacity in any interval.
5. For the interval 0900-0910 the CAISO does not perform any new market optimization, so its previously issued dispatches to the DERA would reflect 5 MW capacity. Thus the DERA may fall short of its DA schedule or RT dispatch. The imbalance on the CAISO system is managed by Regulation (AGC) and will subject the DERA to imbalance energy charges and possibly uninstructed deviation penalties.



Broader gaps for DER market and system integration beyond Order 2222

TRANSMISSION AND DISTRIBUTION PLANNING

- Integrate approach to distribution planning, interconnection, and operations
- Increase coordination between distribution and transmission planning



DISTRIBUTION OPERATIONS

- Identify least-regrets enhancements in visibility, communications, DER operations, and real-time controls that will be needed
- Allocate responsibilities for active coordination of DER activity between the distribution system operator and the ISO/RTO

DISTRIBUTION INTERCONNECTION

- Determine setpoint guidance for smart inverters, given distribution systems' needs
- Define how utilities should determine minimum reliability upgrades versus upgrades that could be avoided through DER curtailment or re-dispatch
- Determine how utilities ensure that procedures for curtailing or re-dispatching flexible interconnections are transparent and non-discriminatory

Broader gaps for DER market and system integration beyond Order 2222 *(continued)*

COMMUNICATIONS AND DATA-SHARING

- Enable increased communication between distribution utilities or distribution system operators and ISOs/RTOs, including during day-ahead and intraday scheduling, real-time dispatch, automatic generation control signals, and emergency operations
- Increase available information on loads, anticipated load growth, and DERs in the interconnection queue

ISO/RTO MARKET DESIGN

- Implement market design changes to enable market-based approaches to load participation during the operating day

MARKET REGULATION

- Ensure that distribution operators' overrides of DER schedules and dispatch and dispatch of DERs are transparent and non-discriminatory
- Clarify issues around state-federal jurisdiction

UTILITY REGULATION AND BUSINESS MODELS

- Implement incentive frameworks that attempt to better align utility incentives with maximizing the system value of DERs
- Design tariffs to incentivize the flexibility that can be provided through energy storage and load management

Recommendations to enable DER integration in wholesale markets

For those at an early stage of DER integration, these strategies can help:

1. **START WITH MINOR CHANGES.** Begin from an assumption that relatively minor changes in distribution planning, distribution operations, and utility investments in monitoring and controls necessary to support them will be needed for near-term compliance with Order 2222 (commissions, utilities).

2. **LEVERAGE EXISTING DATA.** Leverage data from DER registration and interconnection in DER aggregation reviews to minimize the need for additional study during reviews; in most cases, DER aggregation review should not require redoing interconnection studies (commissions, utilities).

3. **USE EXISTING PROCESSES FOR COMMUNICATIONS AND DATA-SHARING.** Rather than create new processes and additional complexity, make use of existing protocols and processes for communications and data-sharing among utilities, aggregators, and ISOs/RTOs (utilities, DER aggregators, ISOs/RTOs).

4. **DEVELOP WORKABLE APPROACHES TO UTILITY OVERRIDES.** Focus initially on developing workable approaches to utility overrides, based on a foundation of efficient communication between utilities and aggregators, with terms and conditions that are clearly articulated in interconnection and aggregator agreements and can evolve over time (utilities, commissions, aggregators).

5. **PRIORITIZE ADOPTION AND IMPLEMENTATION OF IEEE 1547-2018.** Voltage support provided through compliance with interconnection standards may reduce the need for overrides and distribution upgrades (commissions, utilities).

National dialogue

PARTICIPATE IN NATIONAL, INDUSTRY-WIDE DIALOGUE.

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- Build:
  - A **common vocabulary, framework, and vision** for thinking about DER integration across different jurisdictions
  - A common understanding around **shorter-term, least-regrets strategies for DER integration that are consistent across distribution utilities**, including strategies for enhancing distribution and transmission planning, data-sharing and communication, distribution operations, and DER interconnection and aggregation review
  - A **structured dialogue on solutions to longer-term issues around DER integration**, such as the design of distribution system operator (DSO) operations, markets, and regulation, federal-state jurisdictional overlap, independent system operator (ISO) market design, and incentive frameworks for regulated utilities
- Develop a general framework and terminology for considering distribution system operations, markets, and regulation with higher levels of DERs
- Identify nearer-term least-regrets DER integration enhancements and solutions that are grounded in power system engineering and economics and could be applicable to diverse jurisdictions
- Develop a portfolio of potential longer-term DSO models and TSO-DSO coordination arrangements that each jurisdiction could tailor to their individual needs, rather than develop a one-size-fits-all approach

THANK YOU

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