

Distribution-side Energy Market Architecture

MSE Forum, December 9, 2025

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A Local Energy Future Is Both Necessary and Inevitable

Necessary => Today's needs & societal goals require local energy solutions

- Worsening climate disruption, grid vulnerability, energy inequities
- Microgrids for energy resilience; locally owned assets for economic vitality

Inevitable => DERs keep improving in performance, cost & ease to deploy

- Customers, businesses, cities, communities can see huge benefits
- The grid is now contestable — customers with DERs can defect

The big question for policy makers, the industry and all of us =>

**What policies will maximize the benefits for all communities
and manage the challenges of rapid DER proliferation?**

For an equitable High-DER transition => Bottom-up planning & investment

- Plan to meet local energy needs from local supply as much as possible
- **Create a framework to commercialize locally-owned electricity assets**

Why Distribution-side Electricity Markets?

Massive potential for distribution-connected renewable energy supply

- US 39%; CA 74%; New England 47-60% of annual demand from rooftop PV
- NREL study: <https://docs.nrel.gov/docs/fy16osti/65298.pdf> (see Table 6)

Massive benefits from distributed renewable generation + storage

- Deploy on the built environment — no land-use conflicts
- Close to load, no need for transmission
- Can function as grid-forming resources for community microgrids
- Local resource ownership => local economy benefits

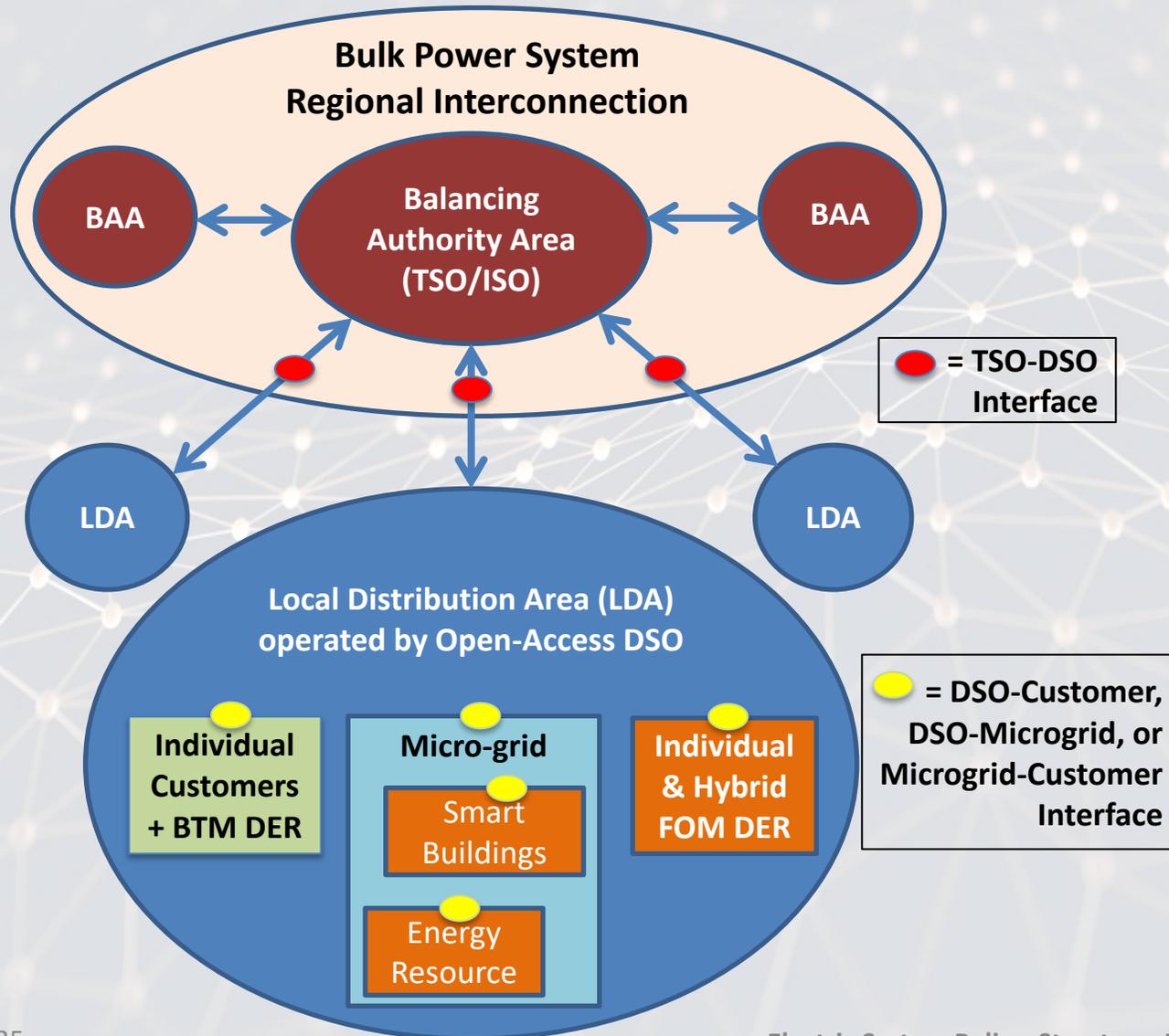
Local ownership of supply assets avoids excessive utility ratebase growth

- Improves affordability — an acute concern for customers and policy makers

Growth in non-utility DERs requires opportunities for economic transactions

- DERs transact energy & grid services, earn revenues & provide system benefits
- Economic participation reduces grid defection incentives
- Supports DER financial viability instead of requiring subsidies

Why Layered Energy Market Architecture?



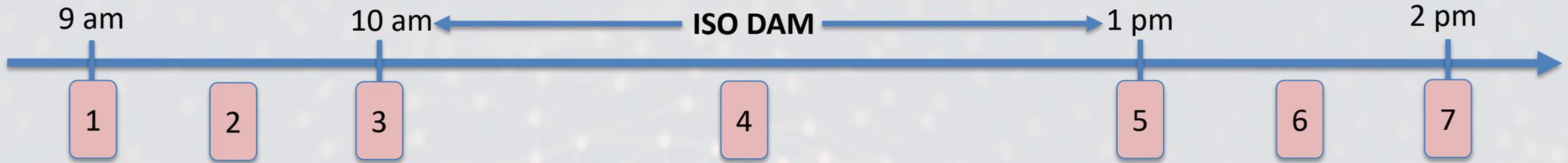
- **Main layers = Bulk System; Distribution System; Network Customer/DER**
 - Multi-customer microgrid may be a layer in between DSO & Customers
- **Each layer manages its interfaces with adjacent layers above & below**
- **Balancing Authority (TSO) interacts with one entity — the DSO — at each T-D interface or ISO pricing node**
- **Focus on interfaces => Operator of each layer does not need visibility or control of assets within the layer below**
- **Interfaces allow for bi-directional flows**
- **Each layer can “island” from layer above at the interface point**
- **Layering simplifies operations & reduces complexity & transaction costs**

Layered Market Operational Structure

Layered system architecture => “Total DSO” =>

- ISO sees one participant — the DSO — at each T-D interface (Local Distribution Area)
- **DSO operates both the distribution network & the local market platform**
- **DSO runs both day-ahead & real-time markets coordinated with wholesale markets, for energy, ancillary services (ISO) & distribution grid services (DSO)**
- **DERs, LSEs (Retailers) & customers participate in ISO markets only through the DSO**
- **Transparent, non-discriminatory DSO market design & rules ensures equal or better economics for all participants, compared to direct participation in ISO markets**
- **DSO market is state/local jurisdictional; only T-D interface transactions by the DSO are interstate commerce & under federal jurisdiction**
- **DSO-TSO coordination at T-D interfaces** is subject to strong, effective performance requirements & incentives to ensure whole-system reliable operation
- **Total DSO role** may be performed by incumbent distribution network utility or a new “independent” DSO **under an open-access regulatory framework**

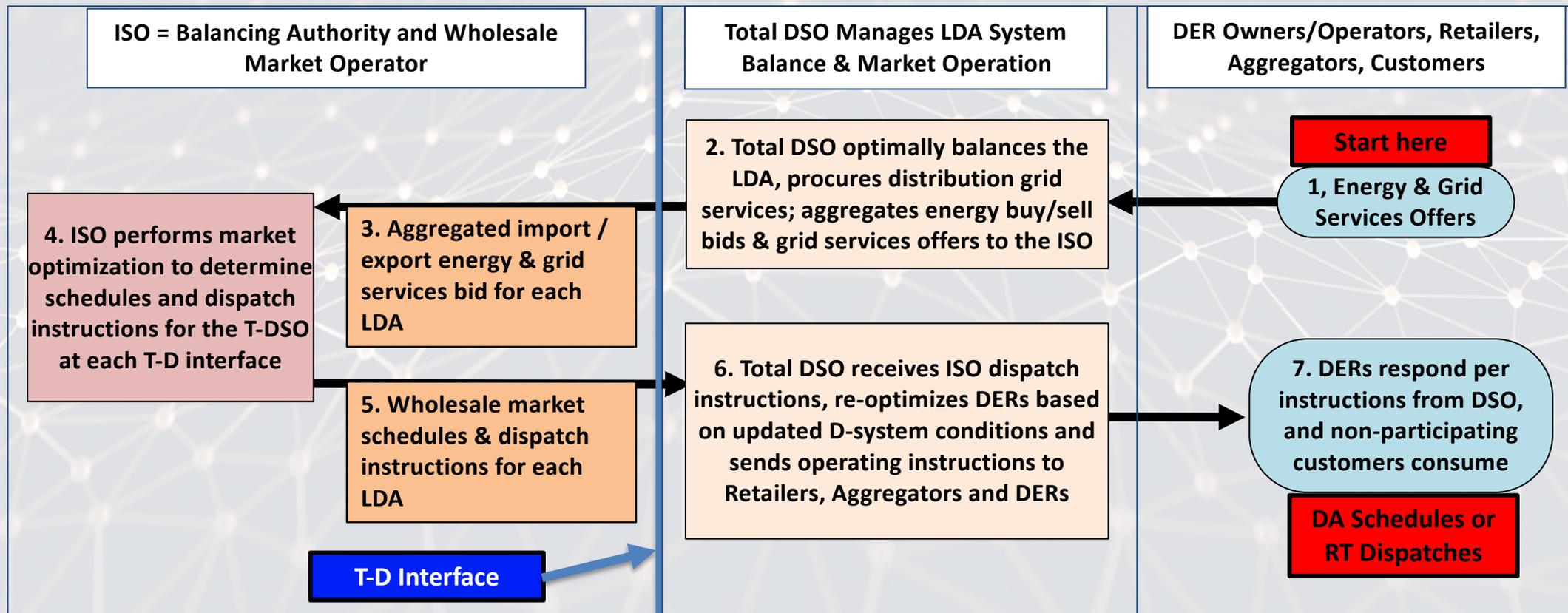
DSO DAM Operation with Typical ISO Market Timeline



1. DERs, Aggregators, Retailers, Customers **submit bids & offers to the DSO market** — for energy, ISO ancillary services & DSO grid services — **hourly for all 24 hours of next day**
2. **DSO runs its DAM to optimally balance supply & demand for the LDA “provisionally”**
 - Designates DERs needed for distribution grid services
 - Uses LMP forecast at T-D interface to price imports/exports from/to ISO
3. **DSO submits to ISO a consolidated bid for the LDA:** energy demand/supply bid curve + ancillary service offers
4. **ISO clears its DAM normally, treating Total DSO as a participating resource**
5. ISO provides DA energy schedules & AS awards to DSO & other ISO market participants
6. **DSO re-optimizes the LDA with known LMP & ISO market awards & updated distribution system conditions**
7. **DSO provides “final” DA energy schedules, ISO AS awards & DSO schedules for distribution grid services to participating resources in the LDA**

Total DSO market coordinated with ISO markets at T-D interfaces

- Applies to both day-ahead and real-time markets. DAM determines hourly day-ahead schedules; RTM determines 5-minute RT dispatch & operation
- Key difference in RTM => non-participating (non-dispatchable) demand does not bid; market clears based on 5-minute load forecasts
- Total DSO performs optimization for each individual T-D interface or Local Distribution Area (LDA)



Benefits of Layered Energy Markets

- ISO deals with 1 entity at each T-D interface: bidding, operation, settlement
- ISO does not need visibility or control to resources or loads within distribution
- ISO-DSO-DER coordination is simpler without DER direct participation in ISO
 - Only 2-party coordination => sequential DER-DSO & DSO-TSO — instead of 3-party coordination — DSO-ISO-DER -- required for direct DER participation in ISO market
- **Total DSO is the ISO market participant**
 - Receives & is responsible to comply with ISO schedules & dispatches
 - Can optimize participating resources within the LDA to reflect current distribution system conditions — avoids curtailment of ISO DER dispatches (FO 2222)
- Participating DERs & customers deal only with DSO, not both DSO & ISO
- **Total DSO market design can ensure participants are not financially harmed by not participating directly in ISO markets**
 - Lower transaction & T-D coordination complexity & costs

The Policy & Architectural Framework

Reform distribution utility as “open-access DSO” =>

- **Open-access network & transaction platform** — analogous to ISO on transmission
- Functions limited to natural monopoly; earnings & regulation tied to performance

Allow sales for resale entirely within state-jurisdictional distribution =>

- No energy backflow onto transmission
- **No interstate commerce**
- Local transactions unencumbered by wholesale market & transmission costs
- **Supports financial viability of non-utility DERs**

Layered operational & market architecture => “Total DSO” model

- A single entity interacts with ISO at each T-D interface
- **Total DSO balances supply & demand within each local distribution area (LDA)**

Combine with bottom-up resource planning + local energy markets =>

- Plan to meet local energy needs from local supply as much as possible
- **Create a framework to commercialize locally-owned electricity systems**

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Thank you

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