



Transactive Energy Systems Perspective

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Trade Secret

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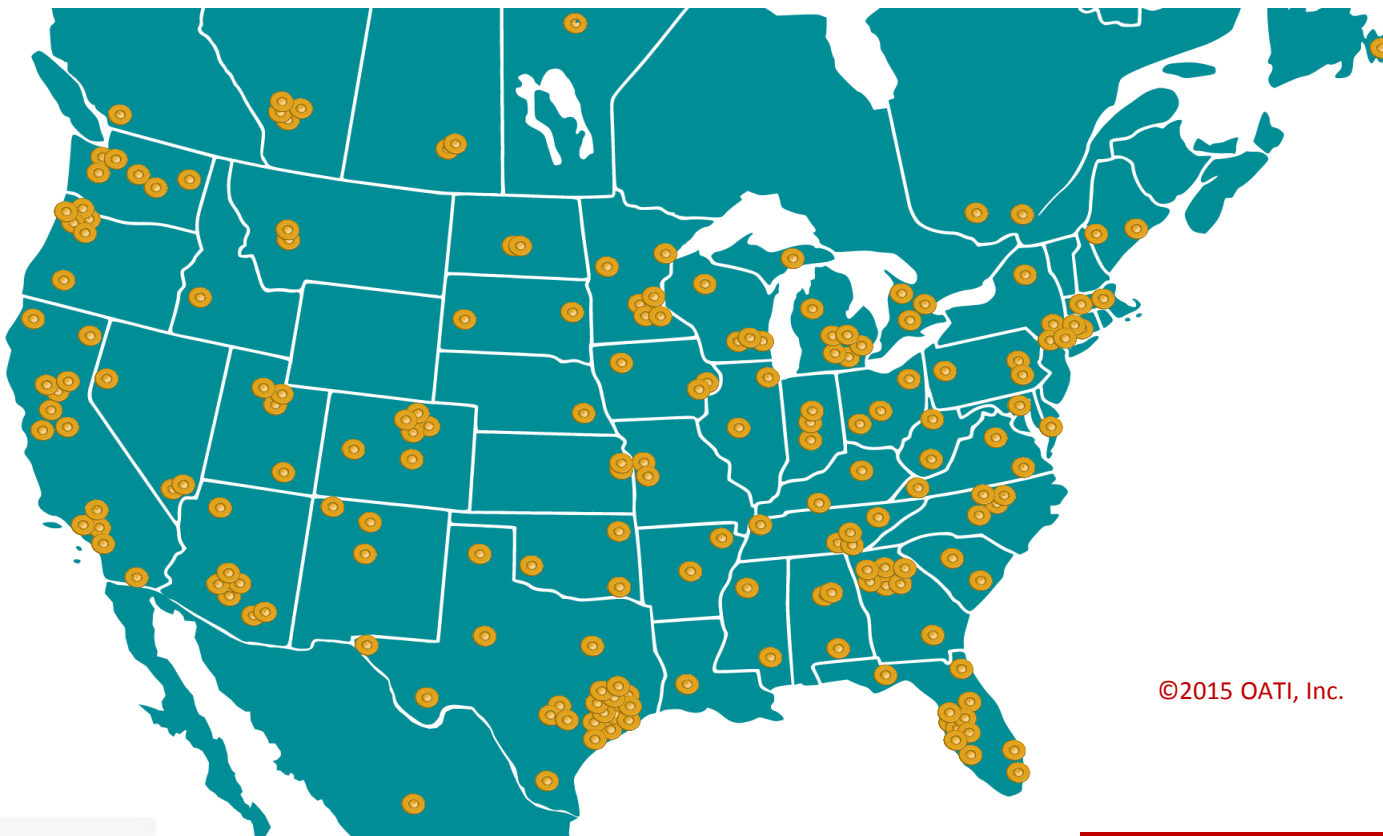
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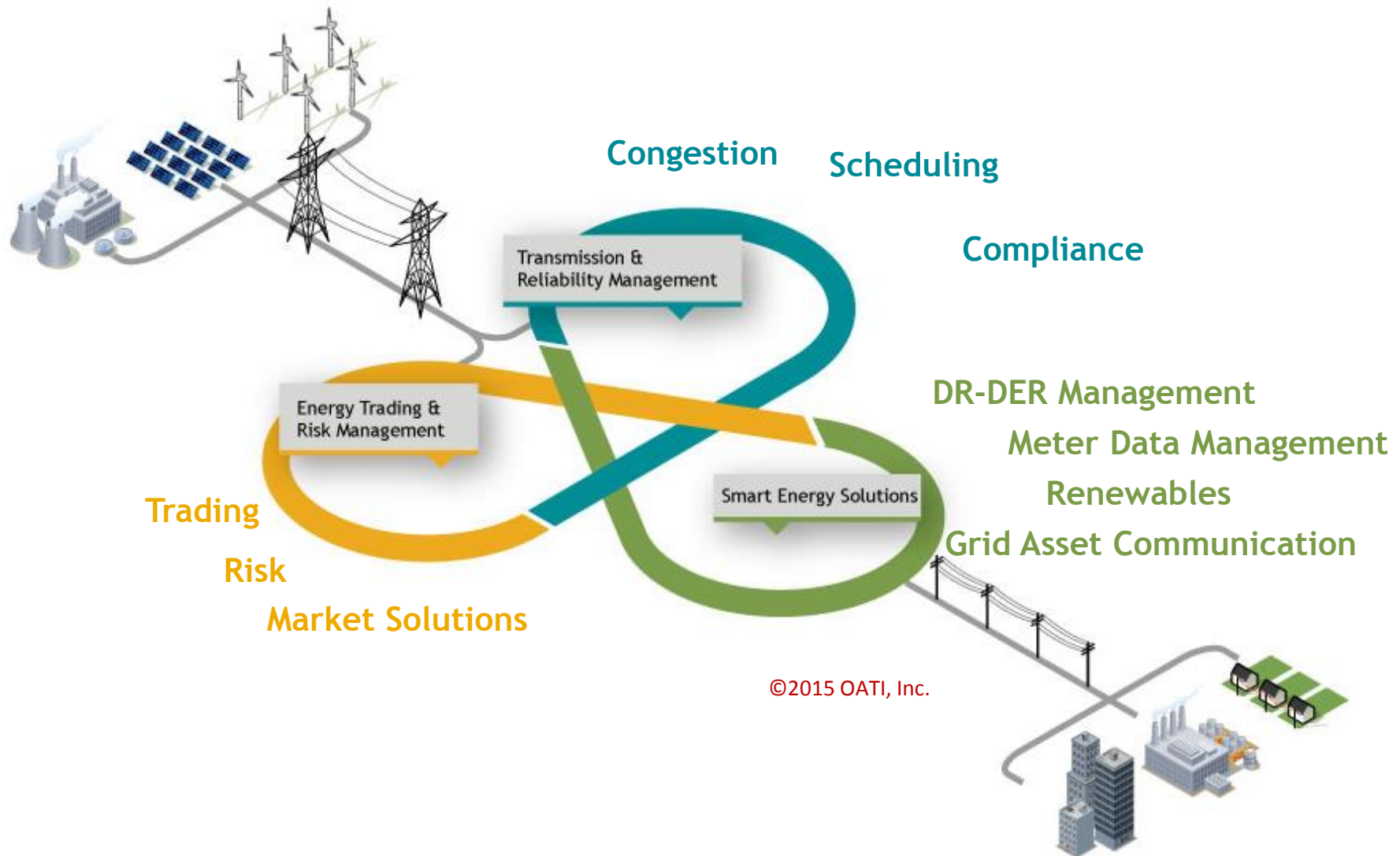
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Transactive Energy Systems Perspective

- The Transactive Energy (TE) systems viewed as extension of existing wholesale transactive paradigm to retail and demand-side with some new attributes and characteristics:
 - *Transactive Actors*
 - Wholesale Markets: Traders, Curtailment Service Providers [CSPs], Load Serving Entity [LSEs], Utility Distribution Companies [UDCs], etc.
 - TE paradigm extends the transactive actors to retail and grid edge domains, including Microgrids, Community Choice Aggregators [CCAs], and intelligent devices
 - *System and Market Operators*
 - Wholesale Markets: ISO/RTOs and Balancing Areas
 - Retail and End-use Transactions: Distribution System Operators (DSOs)
 - *Platform*
 - Wholesale: Transmission Scheduling (TS) and Energy Trading and Risk Management (ETRM)
 - Retail and End-use: Distributed System Platform (DSP)
- Distribution platform can leverage features, functions, and services developed for wholesale ETRM and bulk power operations



Transactive Energy Systems Perspective (Continued)

- Many business processes, rules and procedures, tools and techniques have been developed over the last two decades for management of bulk power operations and wholesale energy markets based on transactive exchanges among various entities
 - *Tools include scheduling, pricing, transmission capacity reservation and transmission rights auctions, and congestion management, both in bilateral and centralized market environments*
 - *Lessons learned from bulk power operations and wholesale energy markets can be applied to transactive exchanges among distributed resources, demand-side operations, microgrids, retail market operators, and distribution system operators under the emerging TE paradigm*



Transmission/Distribution Seams Issues

- Impacts as DER levels increase
 - *Bulk power operations must leverage capabilities available in distribution domain to provide for grid services*
 - *Distribution grid operations*
 - Evaluate DER Hosting Capacity
 - Modify distribution planning and expansion rules and procedures
 - Deal/compensate for loss of revenue
 - *Bulk power substation load forecast*
 - Current method: Using Load Distribution Factors (LDFs) breaks down under DER
 - Need for closer collaboration between the distribution and bulk power system operators to ensure proper forecasting of transmission substation loads



Transmission/Distribution Seams Issues (Continued)

– *Network Phase Balance Issues*

- Bulk power and wholesale energy market operations are based on the assumption of balanced three phase networks. As one gets closer to the feeders and laterals in the distribution system, this assumption breaks down
- Discrepancy can result in unintended consequences when attempting to take wholesale prices to end devices, even when the prices are adjusted to account for distribution losses



Transmission/Distribution Seams Issues (Continued)

- Transactive Operation Modes
 - *Under the TE paradigm, the grid edge devices may operate as transactive agents in one of the following modes at any given time:*
 - Autonomously based on local prosumer preferences
 - In response to bilateral transactive bids and offers
 - In response to market price signals established by a market operator
 - In response to operator instructions
 - *The mode of operation of a grid edge device may transition from one of the above modes to another based on changes in prevailing grid edge device status, temporal considerations, ambient conditions, or system conditions*
 - In normal conditions, it is expected that autonomous, bilateral, bid-based operation, and price-responsive modes would prevail
 - Under emergency system conditions, operator instructions may supersede the mode of operation for some grid edge devices based on established system operation practices such as priority schemes established via electronic tags as practiced in bulk power markets (the term D-Tag^{TM/SM}, for Distribution Tag, is coined to signify such priorities vis-à-vis distribution system constraints)



Transmission/Distribution Seams Issues (Continued)

- Pricing and Cost allocation under the TE paradigm
 - *The Locational Marginal Price (LMP) concept is the basis for energy pricing, payment, and cost allocation in wholesale markets*
 - *Distribution Local Marginal Price (DLMP) is relevant to transactive exchanges within the distribution system, among end-devices and systems, and between distribution/end device and bulk power markets*
 - DMLPs may be long-term or short term
 - Long-term DLMPs primarily to incentivize investments
 - Short-term DLMPs are primarily for settlements among the transacting parties or between the transacting agents and the transactive market operator



Transmission/Distribution Seams Issues (Continued)

- DMLPs may be established based on
 - *The prices-to-devices mechanism used to translate wholesale LMPs into DLMPs taking into account distribution losses, and possibly an uplift for distribution operation costs.*
 - *Local bids/offers, or in their absence constraint violation penalties would establish the DLMPs within distribution constrained areas*



Transmission/Distribution Seams Issues (Continued)

- Differences in bulk and distribution phase balancing can lead to unintended consequences
 - *Example: Transactive Actors*
 - A prosumer having rooftop solar units on a house utilizing Phase A
 - A neighbor using Phase B and charging their Plug-in Electric Vehicle
 - *Results and Observations*
 - Transaction can give rise to excessive phase unbalance and consequent neutral
 - Any constraint imposed on neutral current for reliable distribution system operation would give rise to differential DLMPs on Phases A and B although the two neighbors may have agreed on a single price for their transaction
 - Masking the price differential between Phases A and B amounts to allocating the incremental distribution system operation cost (e.g., increase in losses due to neutral currents) to the rest of the consumers
 - It is conceptually possible to develop DLMPs per phase by incorporating phase unbalance limits, but that brings along “the curse of dimensionality”
 - In the absence of such pricing schemes, it is important for the distribution market operator to track and account for such cost differentials and impute a system operation cost, albeit small, to the culprit transactive parties



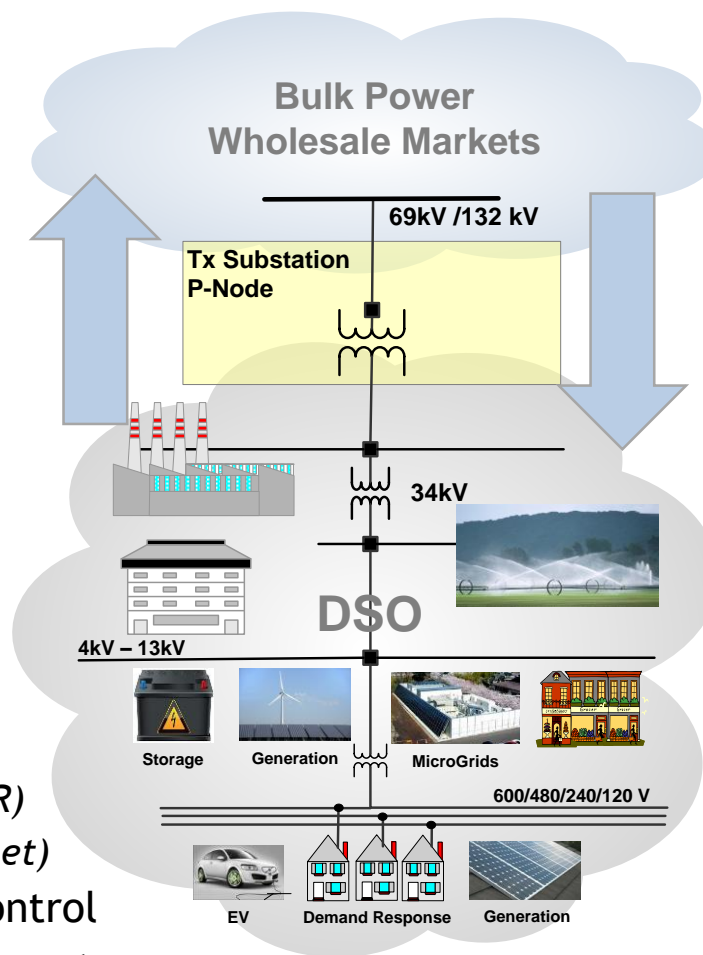
The DSO Construct - Linking Bulk Power and Distributed Resource Operations

DSO to ISO/RTO

- Forecast Net Load and Dispatchable Products
- Schedules and Bids
- Metering and Telemetry

DSO Functions

- Distribution Planning
- Distribution Reliability
- Operations Scheduling
 - Forecasting (Load, DR, DER)
 - Scheduling (DR, DER, Market)
- Dispatch and Real-Time Control
- Retail Metering and Settlements
- Retail Market Administration



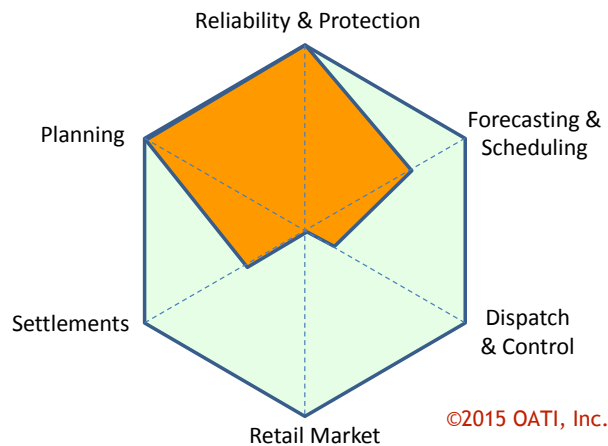
ISO/RTO to DSO

- Schedules
- Dispatch Instructions
- Prices
- Settlements

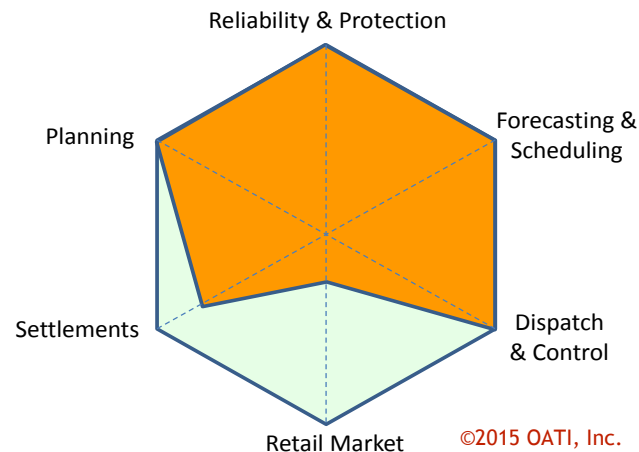
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Different DSO Models

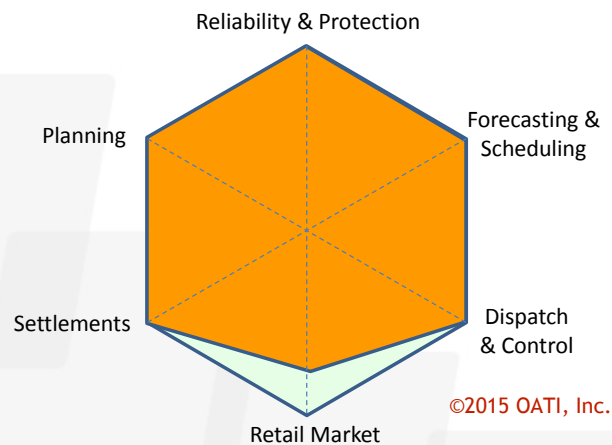
DSO-Lite



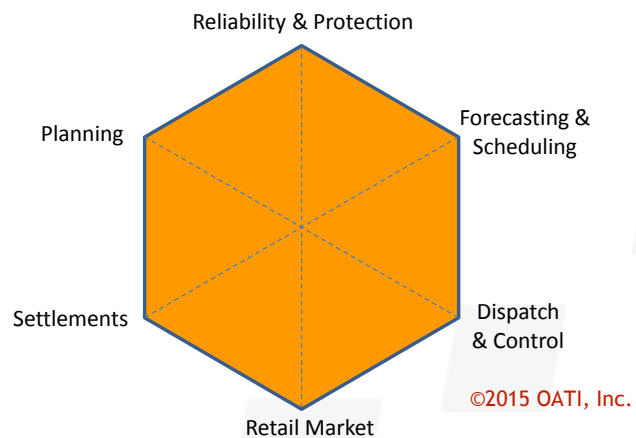
Pseudo BA DSO



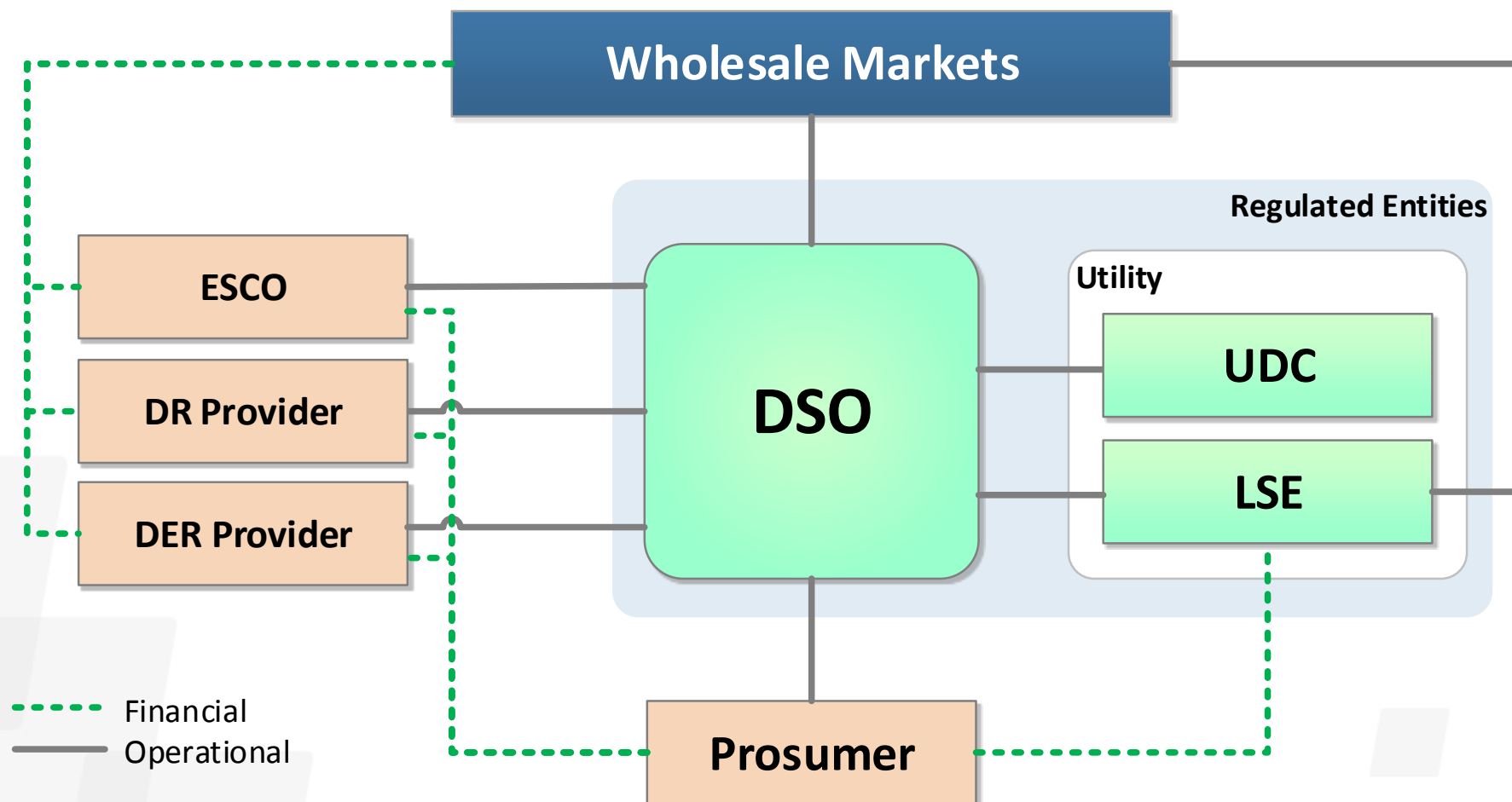
Comprehensive DSO



Maximalist (Fully Transactive) DSO



Transactive Exchanges



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Questions



Thank You

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