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ESIG Meteorology & Market Design For Services Workshop – Denver, June 6-9, 2022

Panel: Integration of Probabilistic Forecasts into the EMS and MMS – Status and Prospects

A Market Management Systems (MMS) Perspective

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June 8, 2022

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Outline

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- Hitachi Energy
- Gird transformation - Integration of renewable/intermittent resources
- Drivers of change and challenges
- MMS: Meeting the challenges
- Forward

About Hitachi Energy

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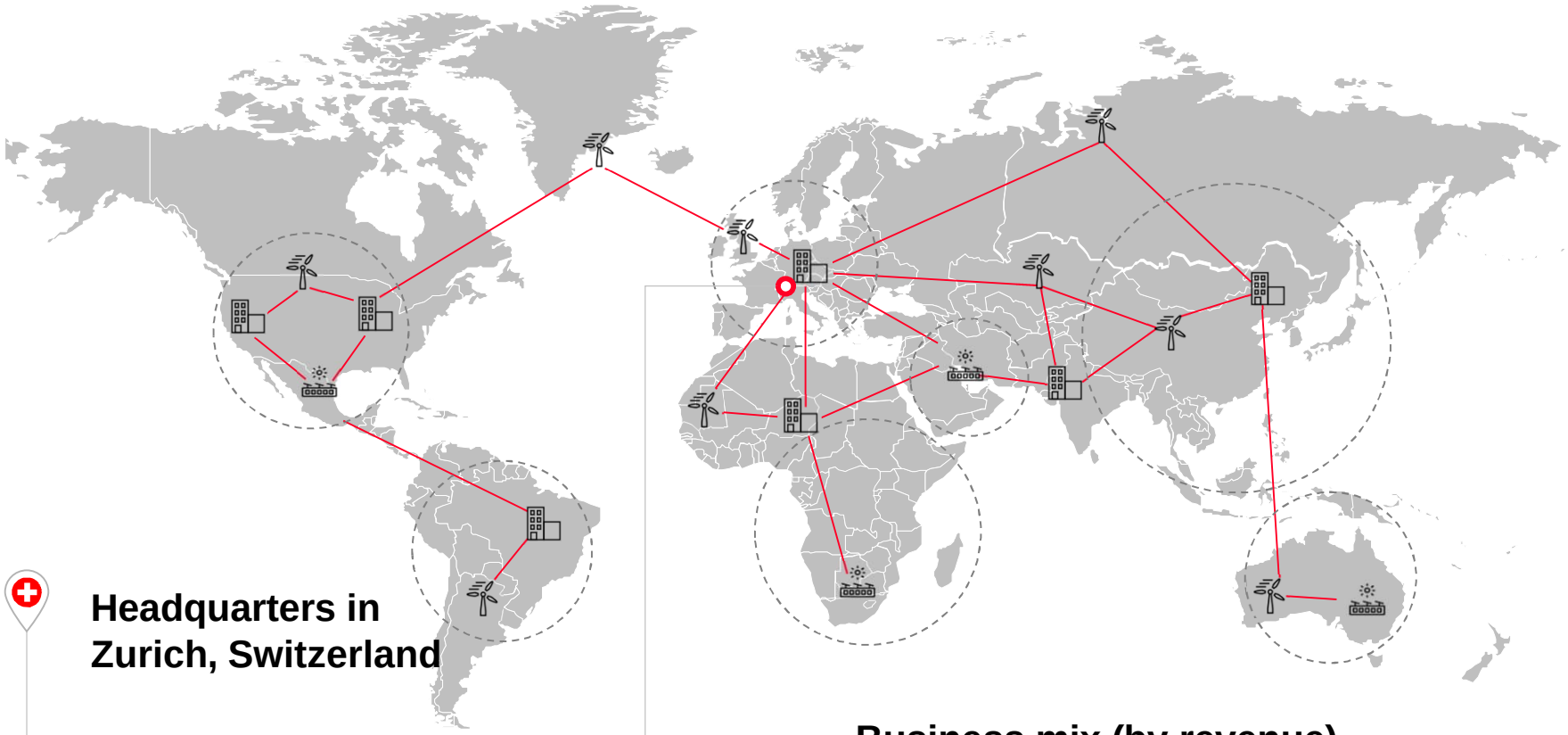

Headquarters in Zurich, Switzerland

38,000 employees

90+ countries with 200 offices

~250 years' heritage combined

5,500 sales employees & field engineers

2,000 engineers & scientists in R&D

Four Business Units

Grid Automation	**High Voltage Products**
Grid Integration	**Transformers**

Business mix (by revenue)

Customers

- Transport & Infrastructure
- Industry
- Utilities

Offering

- Services
- Software & Automation
- Systems
- Products

Geographies

- Asia, Middle East & Africa
- Americas
- Europe

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Grid Automation | A pioneering leader since 1905

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Comprehensive portfolio of solutions…

Substation Automation	Communication Networks	Grid Automation Services	Grid Edge Solutions	Enterprise SW & Network Control

…addressing all key segments connected to the energy system

Generation	Transmission Distribution	Industries	Transportation	Infrastructure

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Grid Transformation

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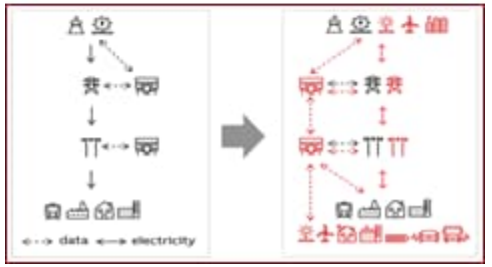
- **Restructuring (1990's)**
  - Unbundling of vertical utilities
  - Electricity markets
  - ISO/RTO's (Central Dispatch), TSO's (Balanced Scheduled)

- **Changing Utility Landscape (2000's)**
  - Renewables and smarter grid resources
  - Changing resource characteristics
  - Increasing intermittency

- **Emerging Business Model (2010's)**
  - Rise of distributed energy resources (DER)
  - Two-way flows: within DX and DX-TX
  - "Transactive Energy"



Integration of Renewables/Intermittent Resources – Challenges

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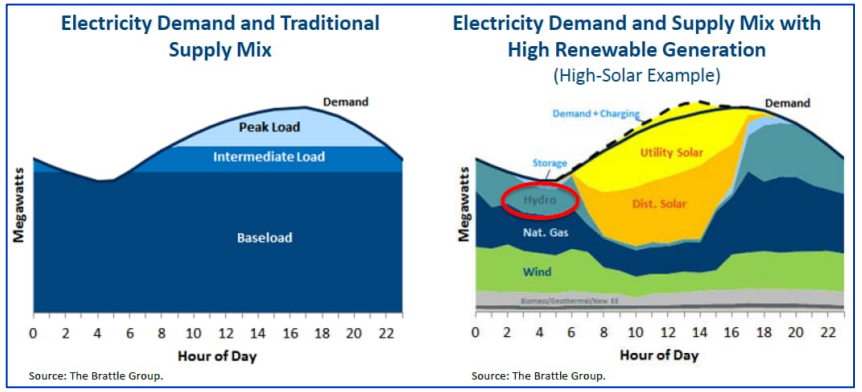
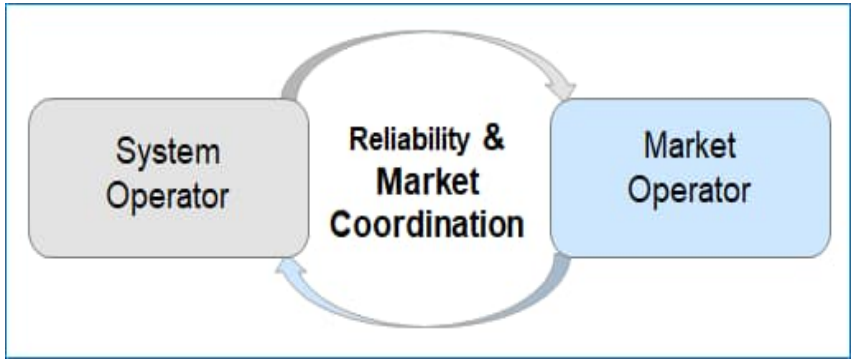
- Stochasticity
  - Increasing load and generation uncertainty
  - Less accurate forecasting
- Generation and load non-alignment
- More stressed transmission
  - Higher and more volatile flows, etc.
- Increasing number of smaller resources
- Lower system inertia

- Efficiency vs. reliability & resilience





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Meeting the Challenge

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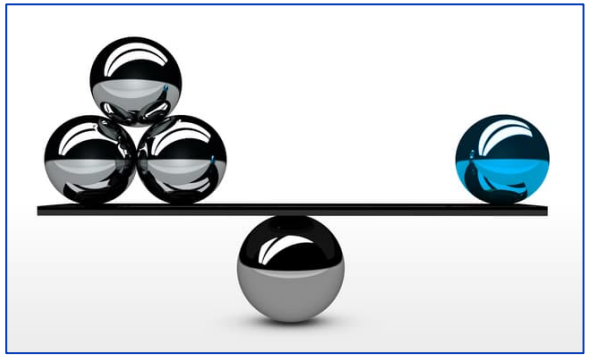
- Better forecasting – distributed and hierarchical
- Higher levels of grid flexibility
  - Look-ahead capability – longer horizon and finer time intervals
  - Generation flexibility and ramping capability
  - Flexible demand
  - Energy storage
  - More flexible & dynamic reserves
- Optimal utilization of transmission assets
  - More realistic modeling
- Co-optimization

- *Higher performance scheduling/market clearing engines*



Look-ahead capability – longer horizon and finer time intervals

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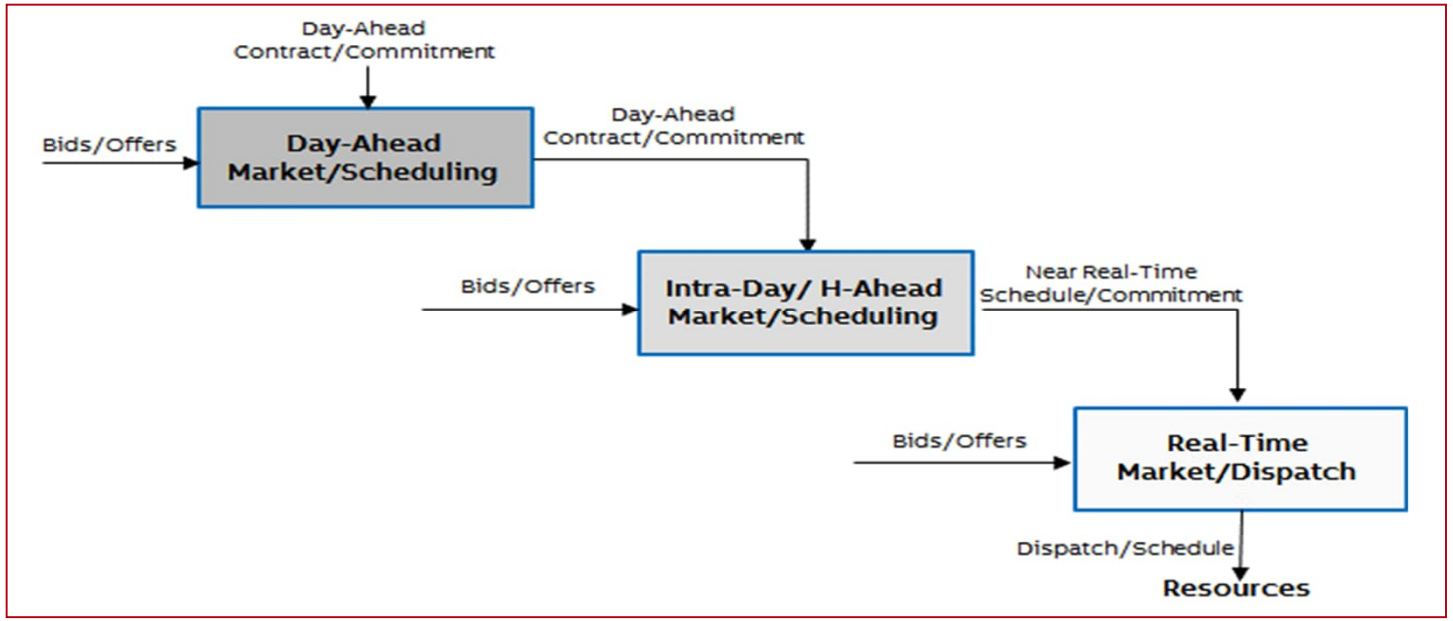
- Multi-interval optimal scheduling and dispatch
  - Day Ahead, Intra-Day, Real-Time
- Reliability Scheduling
  - Multi-day, multi-week, etc.
- Co-optimization of energy, ancillary services, etc.



Resource Flexibility – Generation and Reserves & Transmission

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- Generation Models
  - Combined Cycle Plants (CCP)
    - Optimal configuration determined by market clearing engine
  - Fast Start Units
- Complex reserve models
  - MW dependent reserve capability
  - System level and local reserve constraints
- Ramp Model
  - MW change rate a function of generation level
  - Convex and non-convex models
  - Forbidden regions
- Transmission
  - Post Contingency Correctives, PAR, Remedial Actions, etc.

Energy Storage

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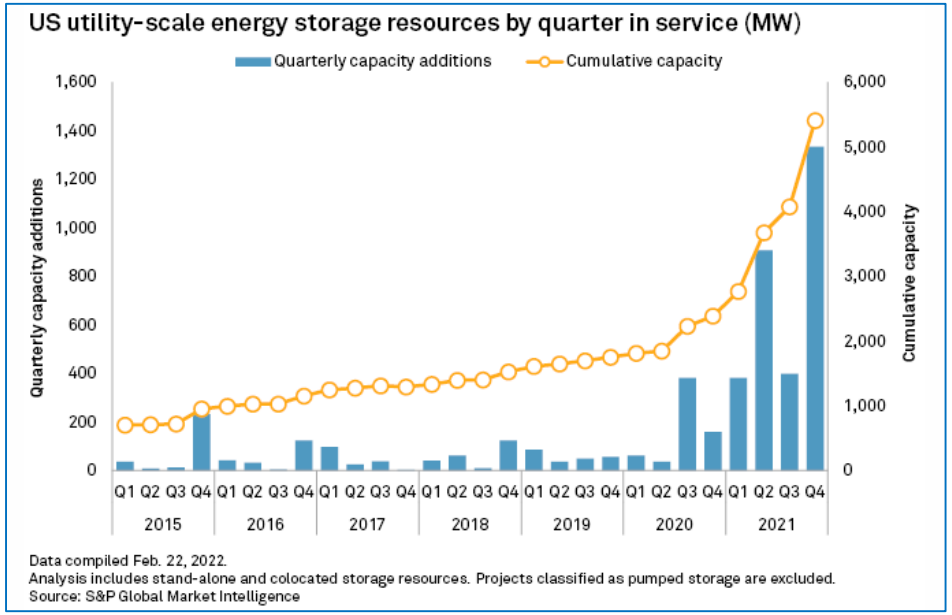
- Various Storage Types
  - Flywheels
  - Pumped Hydro Storages (PHS)
  - Energy Storage Resources (ESR) – Batteries, etc.
- Operational Storage Models
  - Ireland I-SEM (PHS)
  - UK National Grid (PHS)
  - NYISO (Flywheel, PHS, ESR)
- FERC Order 841 Compliance
  - NYISO ESR



Latest Features/Functionalities – NYISO Examples

- Development
  - Large Scale Solar on Dispatch
  - Hybrid Co-Located / Energy Storage Resources
  - Fast Start Pricing
  - Reserves for Resource Flexibility
  - Ancillary Services Shortage Pricing
  - DER Integration
- Investigation
  - Duct Burner Modeling
  - Dynamic Reserves
  - Transmission Shortage Pricing

Large Scale Solar on Dispatch

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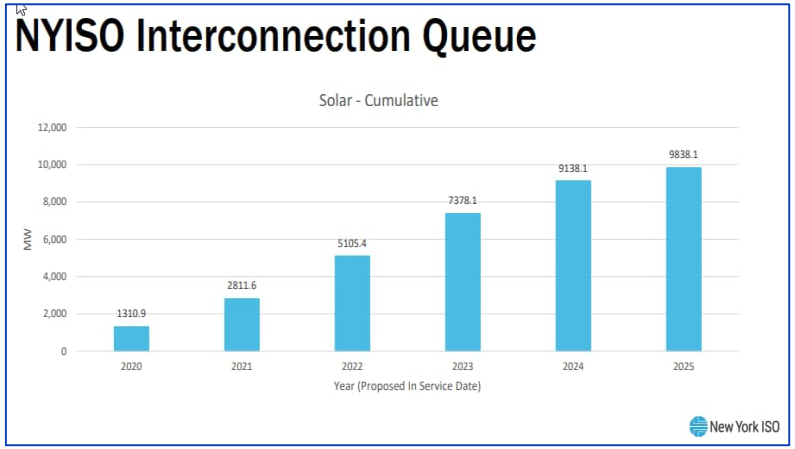
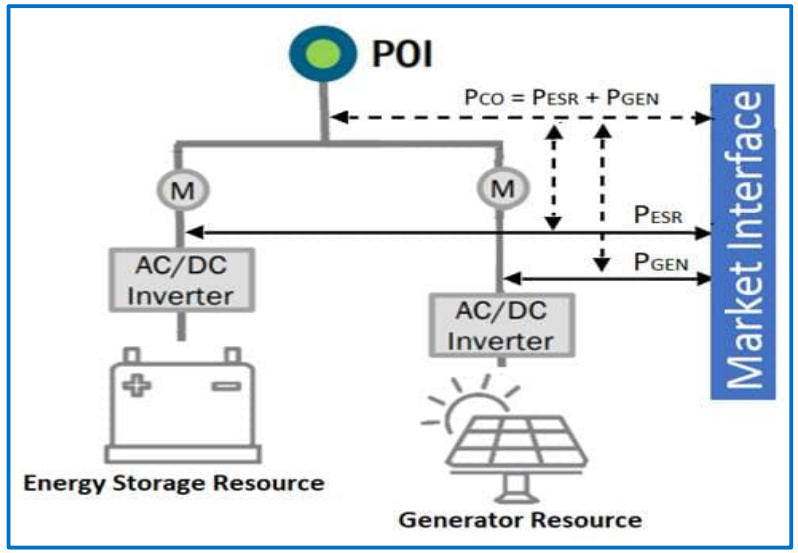
- Front-the-meter solar resources treated similarly to wind resources
  - Resource submits real-time offers and responds to economic dispatch
  - Not eligible for Day-Ahead Margin Assurance Payments
  - Eligible for over-generation charges when subject to economic curtailment signal
- Benefits
  - Minimize magnitude & duration of necessary resource limitations - avoid less-efficient out-of-market curtailments
  - Allow solar resources to set market prices
  - Avoid negative pricing
  - Additional flexibility

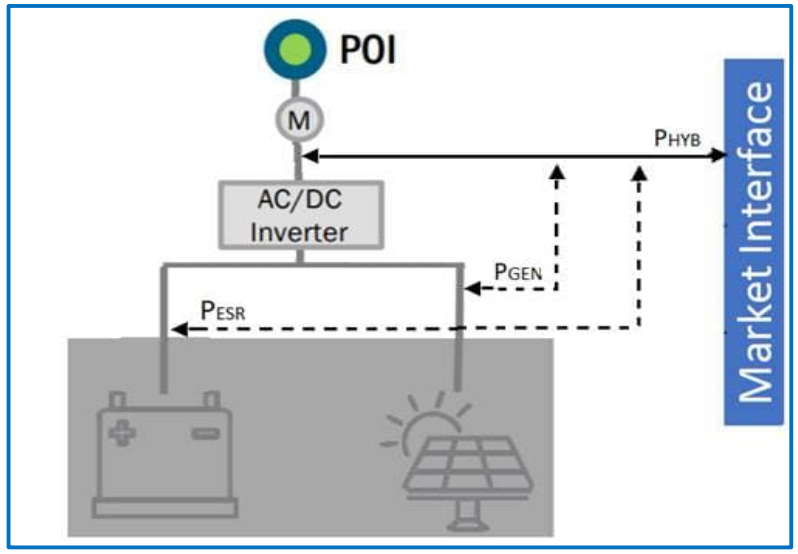


Co-Located and Hybrid Resources

- Co-located Storage Resource (CSR):
  - A single intermittent renewable resource and a single energy storage behind a single Point of Interconnection
  - Both units have distinct PTID / Capacity /Energy Bid / Energy Schedule / Settlement
  - Interconnection limit is treated as a hard constraint /time-dependent
  - Total CSR output (energy, regulation and reserve) is equal to or less than the POI



- Hybrid Storage Resource (HSR):
  - Combination of generation and energy storage units co-located behind a single Point of Interconnection, that participates in the wholesale market as a single resource with a single PTID.



More Flexibility and Higher Efficiency

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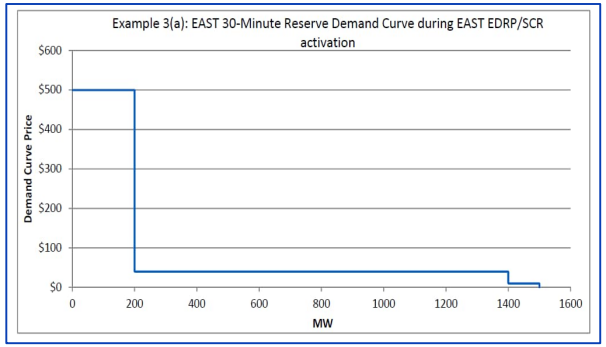
Ancillary Services Shortage Pricing:

- Incentivize higher levels of reserve availability and grid flexibility
- Revised reserve demand curves and adjusted shortage pricing values



Reserve for Resource Flexibility:

- More optimal allocation of locally required reserves
- Reduced out-of-market actions to return facilities to Normal Transfer Criteria following a contingency

Enhanced Fast-Start Pricing:

- Relaxation of all dispatchable fast-start resources' min operating limits by up to 100% for the purpose of setting prices
- Eligible to set prices during the intervals in which they are called upon
- Start-up and no-load costs are reflected in the prices

Distributed Energy Resources (DER) Integration

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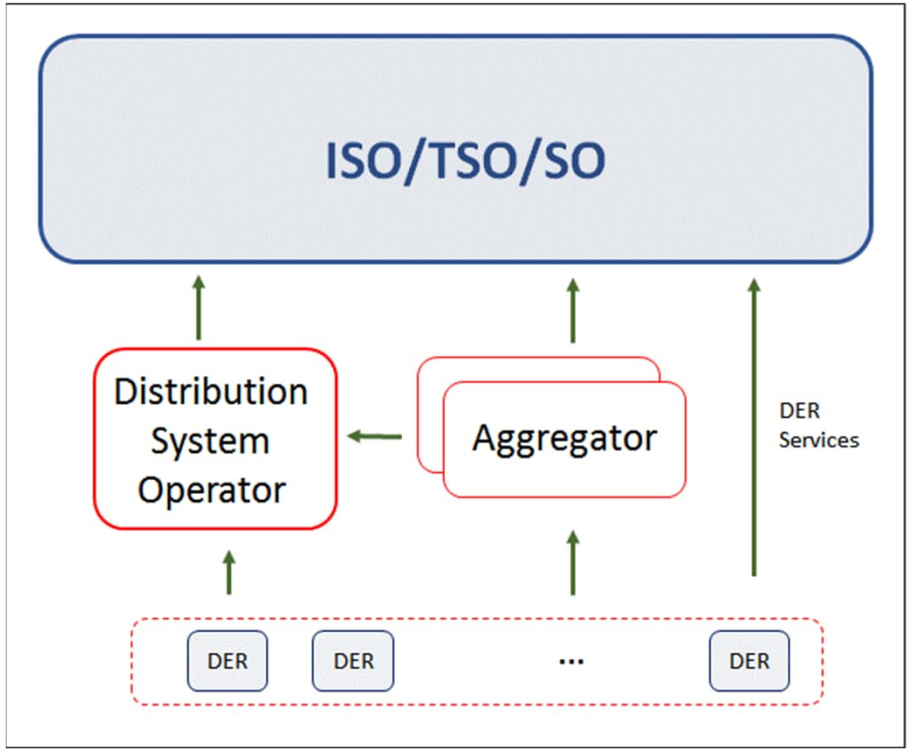
- FERC Order No. 2222 requires ISOs to permit DER participation alongside traditional resources in the organized wholesale markets through aggregations.
- DERs can participate in the wholesale market directly or through an “aggregator.”
- Individual DERs or their aggregates are represented at their respective interface by their bids/offers
- NYISO DER Participation Model



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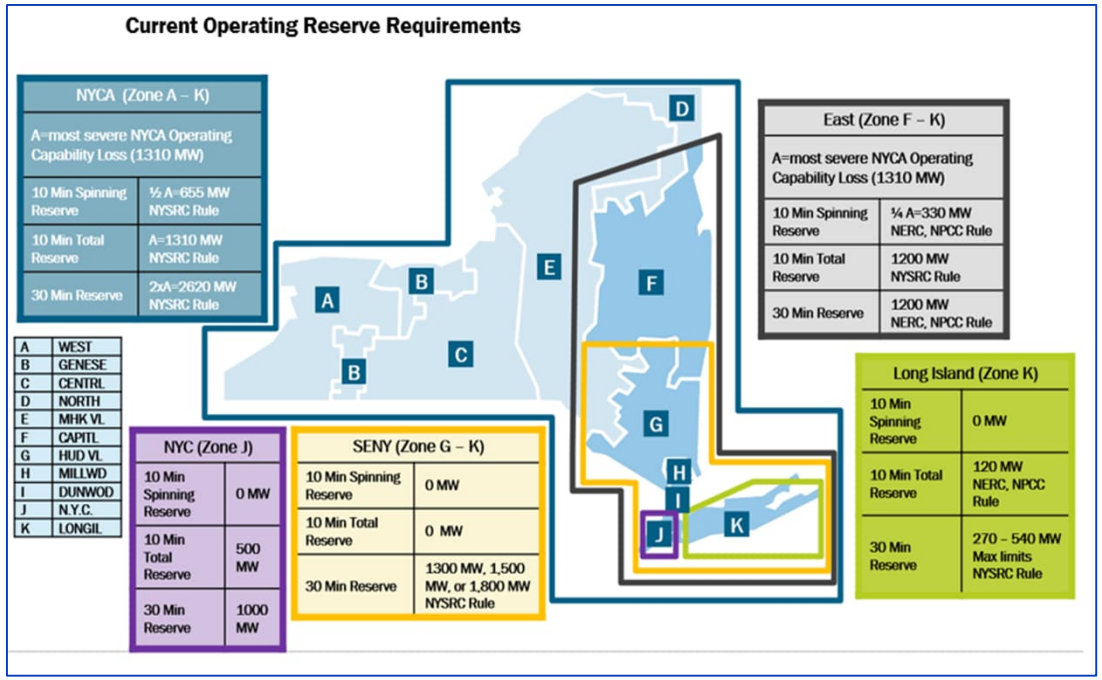
Dynamic Reserves

- Increasing intermittency necessitates scheduling adequate reserves in import-constrained locations
- Existing reserve requirements are essentially static
- A dynamic reserve procurement methodology should improve market efficiency & system reliability
- Investigation:
  - Dynamically determining the minimum local operating reserve requirements
  - Dynamically shifting reserve procurements to lower-cost regions based on available transmission capability



Improved Duct-Firing Cycle Model

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Background

- Reserves and regulation resources are required to achieve their emergency response rate over their entire range
- Most combined-cycle (CC) gas turbines include duct firing - response rates are typically slower and not modeled
- This limits availability of such resources to provide reserves and regulation
- Evaluate market enhancements to more accurately model resource

Modeling and computational complexities:

- Generic convex and non-convex multi-step resource response models

- Expected Benefits:

- Additional dispatchable capacity is of increasing value as intermittent resources grow
- Market efficiency, reserve availability and grid reliability

Summary

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- Advanced modeling and analytical capabilities to address integration of intermittent resources and load stochasticity
- More realistic modeling key to higher market efficiencies and grid reliability
- Ever increasing need for higher performance scheduling and market clearing solutions:
  - More efficient models and problem formulations
  - MIP Tuning
  - New algorithms


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