

INTERNAL

HITACHI
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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

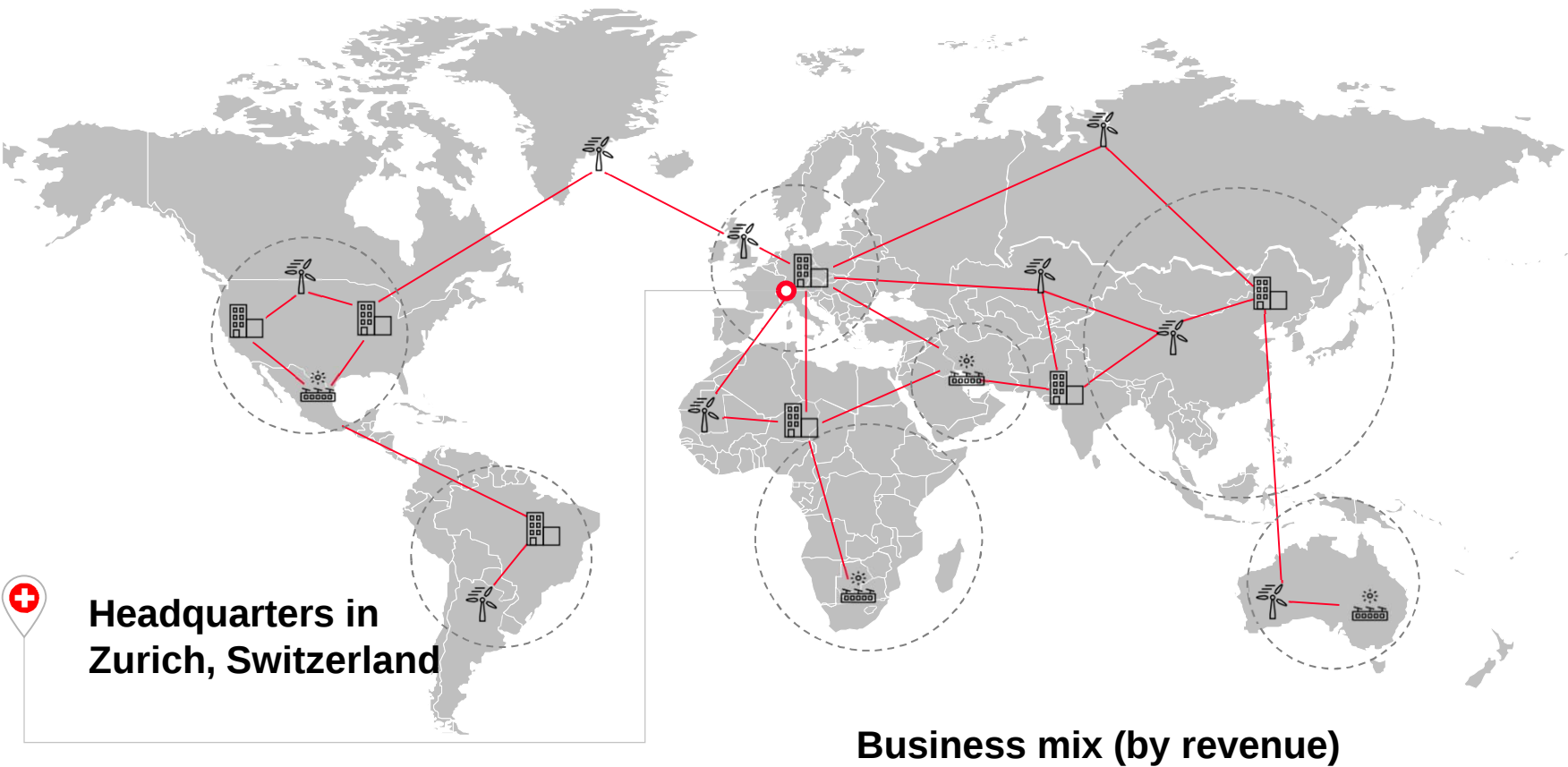
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June 8, 2022

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



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

Customers

- Transport & Infrastructure
- Industry
- Utilities

Offering

- Services
- Software & Automation
- Systems
- Products

Geographies

- Asia, Middle East & Africa
- Americas
- Europe



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

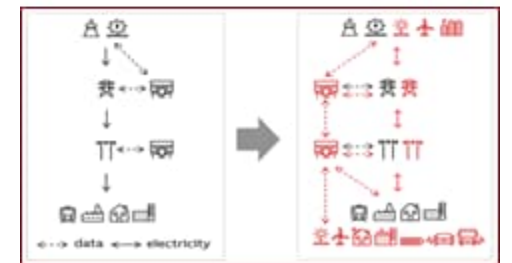
Transmission
Distribution

Industries

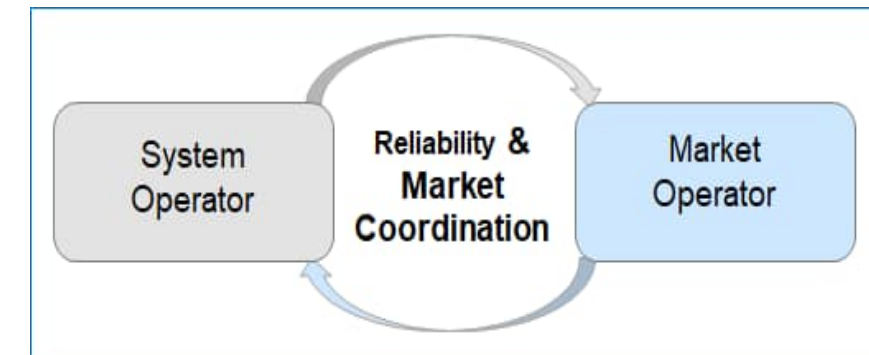
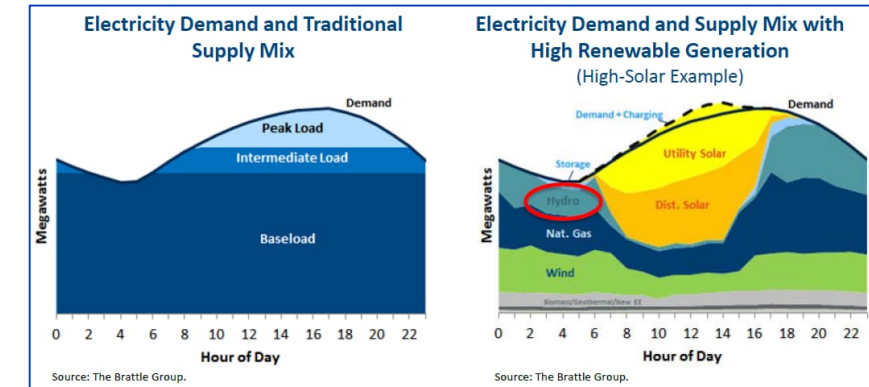
Transportation

Infrastructure

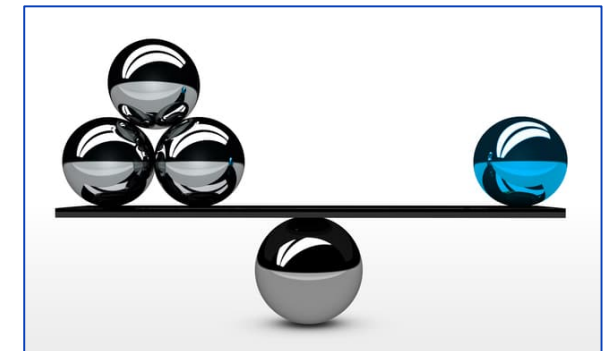
- **Restructuring (1990's)**
 - Unbundling of vertical utilities
 - Electricity markets
 - ISO/RTO's (Central Dispatch), TSO's (Balanced Scheduled)
- **Changing Utility Landscape (2000's)**
 - Renewables and smarter grid resources
 - Changing resource characteristics
 - Increasing intermittency
- **Emerging Business Model (2010's)**
 - Rise of distributed energy resources (DER)
 - Two-way flows: within DX and DX-TX
 - "Transactive Energy"



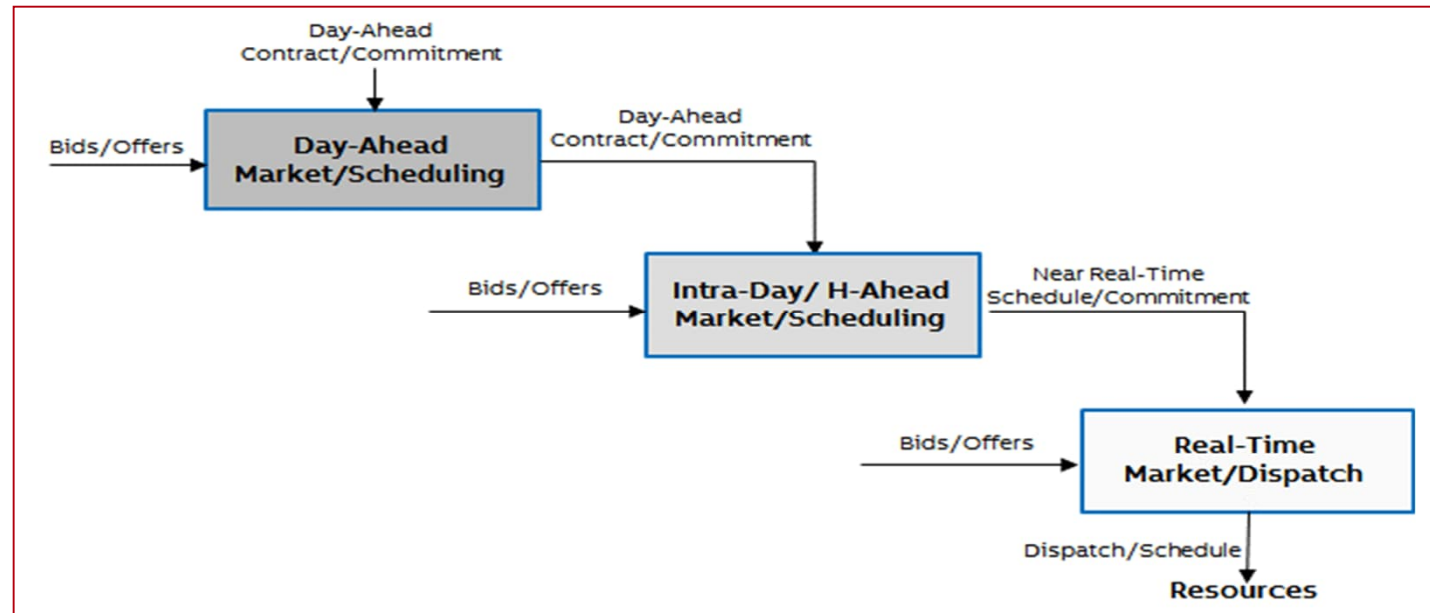
- Stochasticity
 - Increasing load and generation uncertainty
 - Less accurate forecasting
- Generation and load non-alignment
- More stressed transmission
 - Higher and more volatile flows, etc.
- Increasing number of smaller resources
- Lower system inertia
- Efficiency vs. reliability & resilience



- 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*



- 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.



- **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.

- Various Storage Types

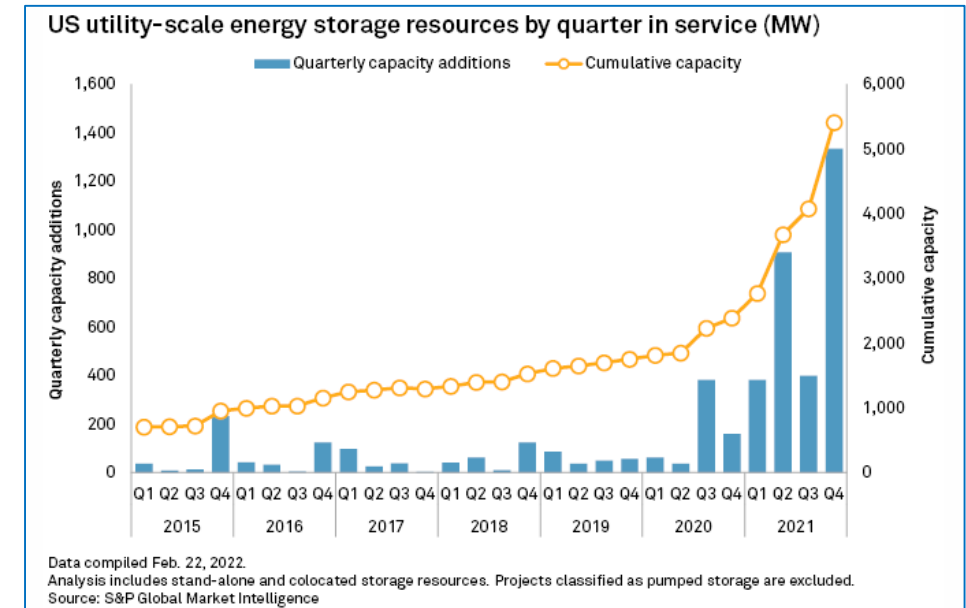
- Flywheels
- Pumped Hydro Storages (PHS)
- Energy Storage Resources (ESR) – Batteries, etc.

- Operational Storage Models

- Ireland I-SEM (PHS)
- UK National Grid (PHS)
- NYISO (Flywheel, PHS, ESR)

- FERC Order 841 Compliance

- NYISO ESR



- **Development**

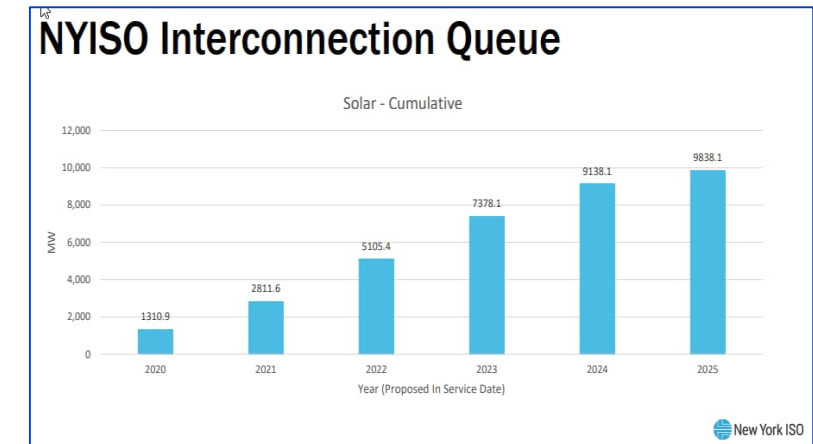
- Large Scale Solar on Dispatch
- Hybrid Co-Located / Energy Storage Resources
- Fast Start Pricing
- Reserves for Resource Flexibility
- Ancillary Services Shortage Pricing
- DER Integration

- **Investigation**

- Duct Burner Modeling
- Dynamic Reserves
- Transmission Shortage Pricing

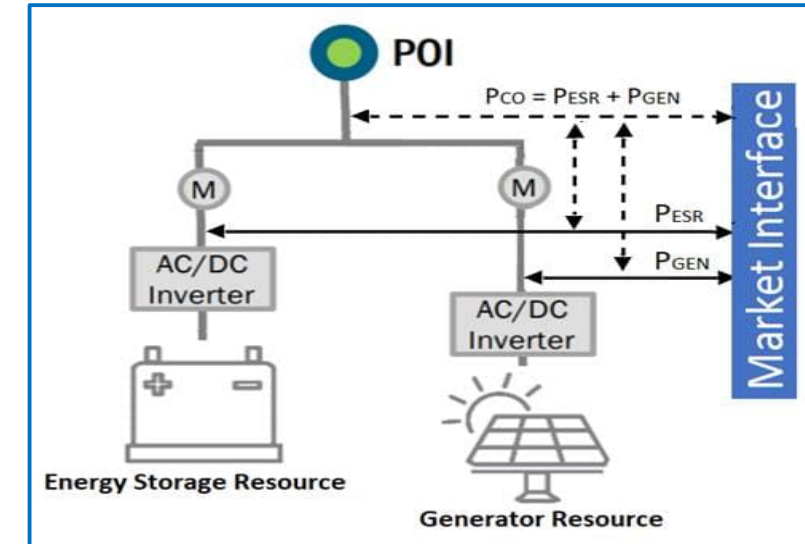


- Front-the-meter solar resources treated similarly to wind resources
 - Resource submits real-time offers and responds to economic dispatch
 - Not eligible for Day-Ahead Margin Assurance Payments
 - Eligible for over-generation charges when subject to economic curtailment signal
- Benefits
 - Minimize 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



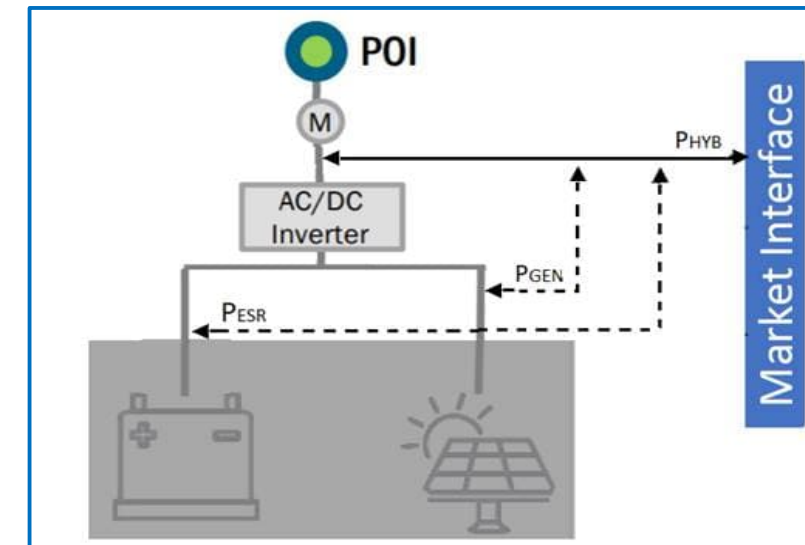
- Co-located Storage Resource (CSR):

- 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



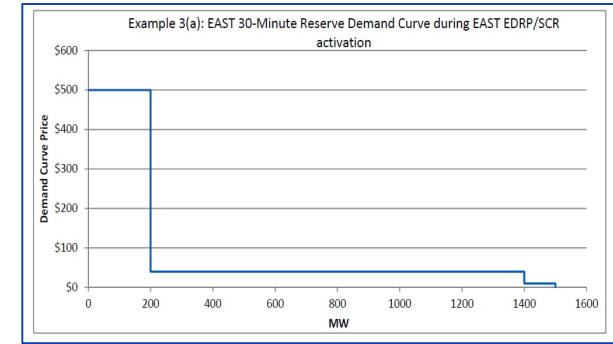
- Hybrid Storage Resource (HSR):

- 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.



Ancillary Services Shortage Pricing:

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



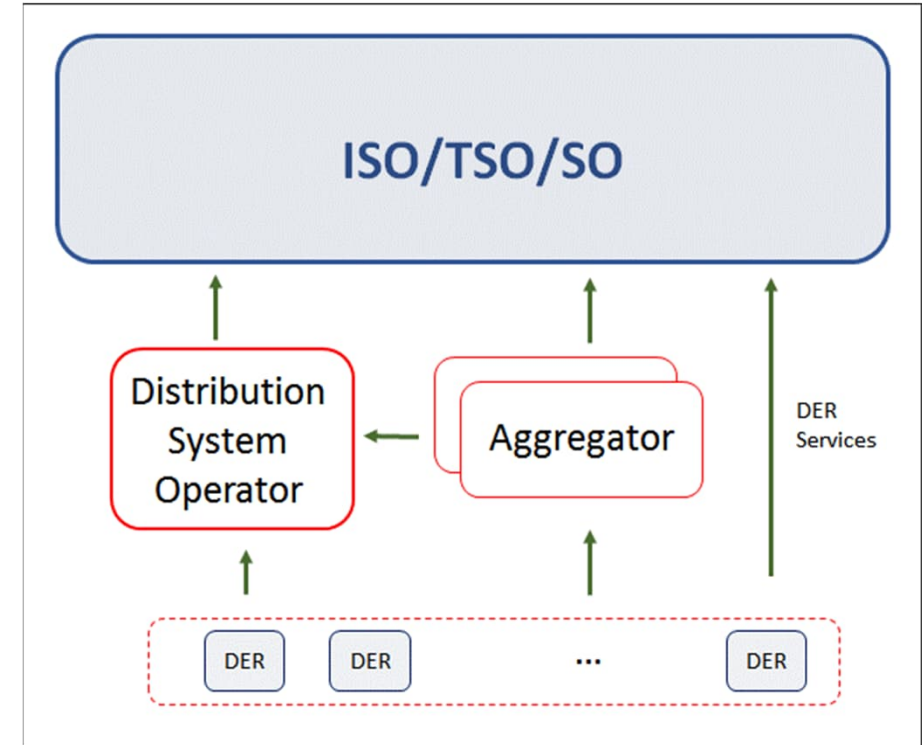
Reserve for Resource Flexibility:

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

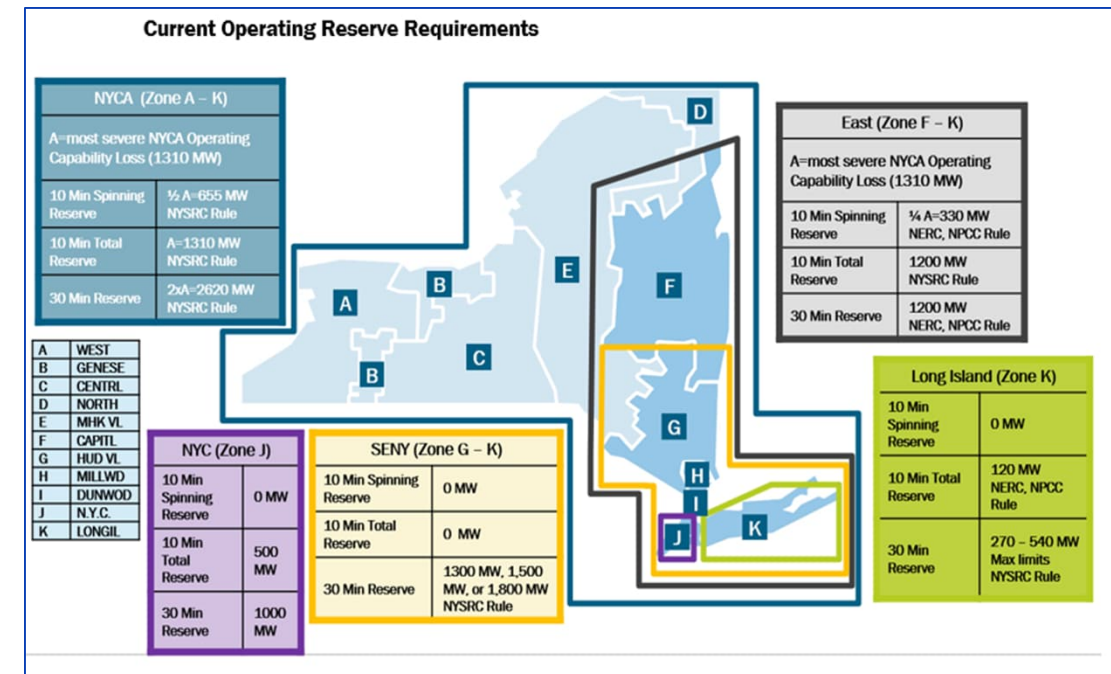
Enhanced Fast-Start Pricing:

- 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

- 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



- 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



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

- 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

