Day-Ahead Enhancements

Technical Session 2

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Format of These Sessions

- This is NOT a Markets Committee meeting and will not follow normal MC rules (posting, interactive WebEx, etc.)
- Sessions are meant to help the ISO frame the problem and potential solution set. ALL input is welcome and essential
- We will end the session summarizing key conclusions

Important Note on Today's Session

- This session will answer the following question:
  - How do other ISOs satisfy next-day reliability requirements?
- This session will not discuss winter energy security or current ISO proposals on that topic
  - Specifically, it will not address multiple day-ahead markets

First Things First: A Prominent Disclaimer

- The following descriptions of other ISO/RTOs' DAM practices are based on our best knowledge
- We have endeavored to ensure the accuracy of all explanations and examples
- However, it is possible that this information **may not exactly match** what other ISO/RTOs currently do, or plan to do in the future
- Any errors that remain are solely the authors' responsibility, and corrections supported by other ISO/RTOs' documentation would be appreciated

This Session

- Review of the previous session
- Discussion of **how other ISOs satisfy the similar DA reliability requirements**
  - NYISO
  - PJM
  - MISO
  - SPP
  - CAISO
  - ERCOT
- Key takeaways

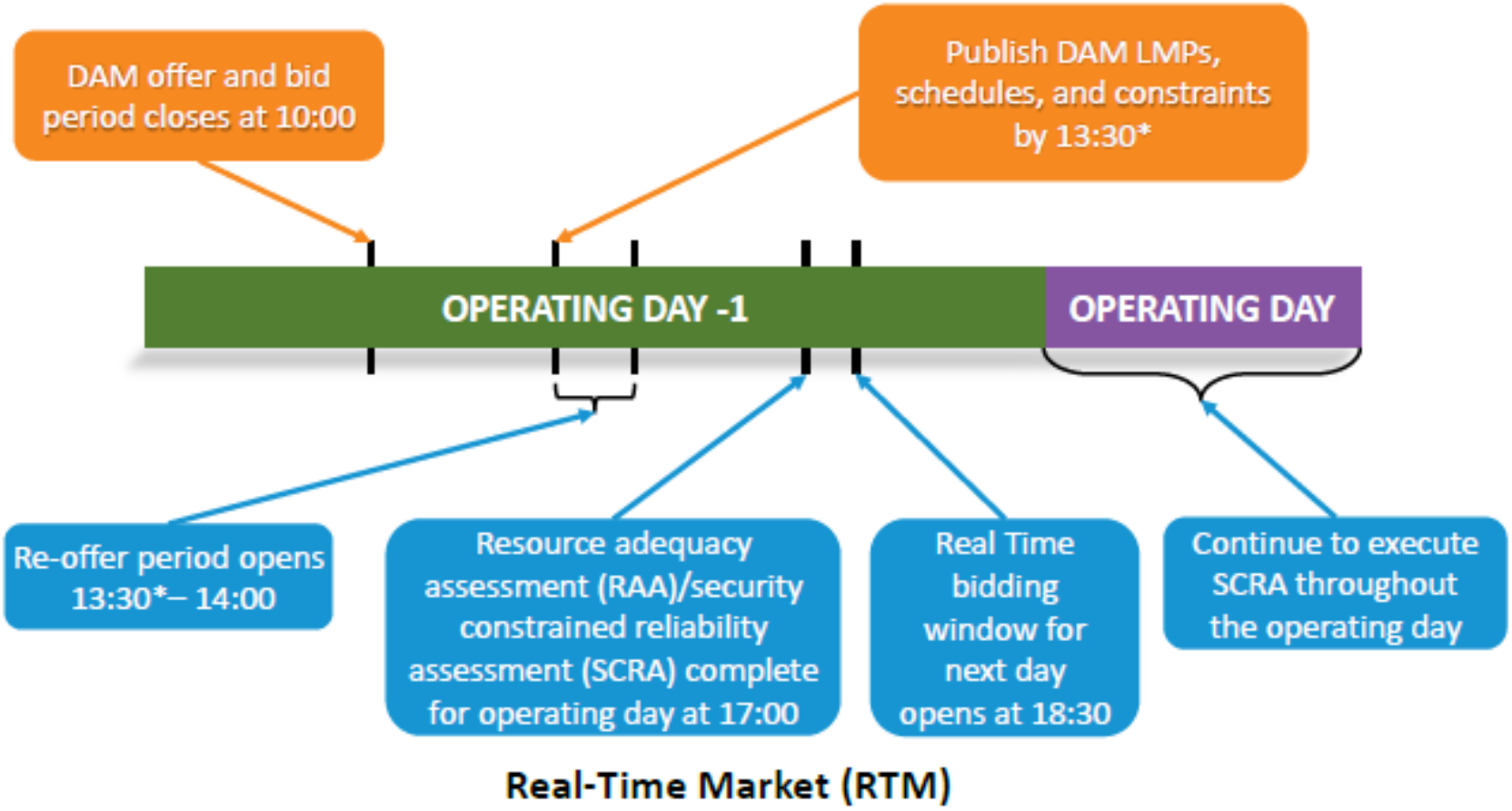
REVIEW OF THE PREVIOUS SESSION

ISO-NE Day-Ahead (DA) Processes

1. DA Market (DAM)
   - Solve commitment, dispatch, and pricing based on **bid-in load**
   - Output includes
     - Financially binding quantities and prices
     - Planned next-day commitments for non-fast start (non-FS) generators
2. Reserve Adequacy Analysis (RAA)*
   - Respecting planned commitments from the DAM, solve supplemental commitment and dispatch based on **forecasted load**
   - Output includes
     - Additional planned next-day commitments for non-FS generators

* Also known as Resource Adequacy Assessment

Timeline



See WEM101: Day-Ahead Energy Markets

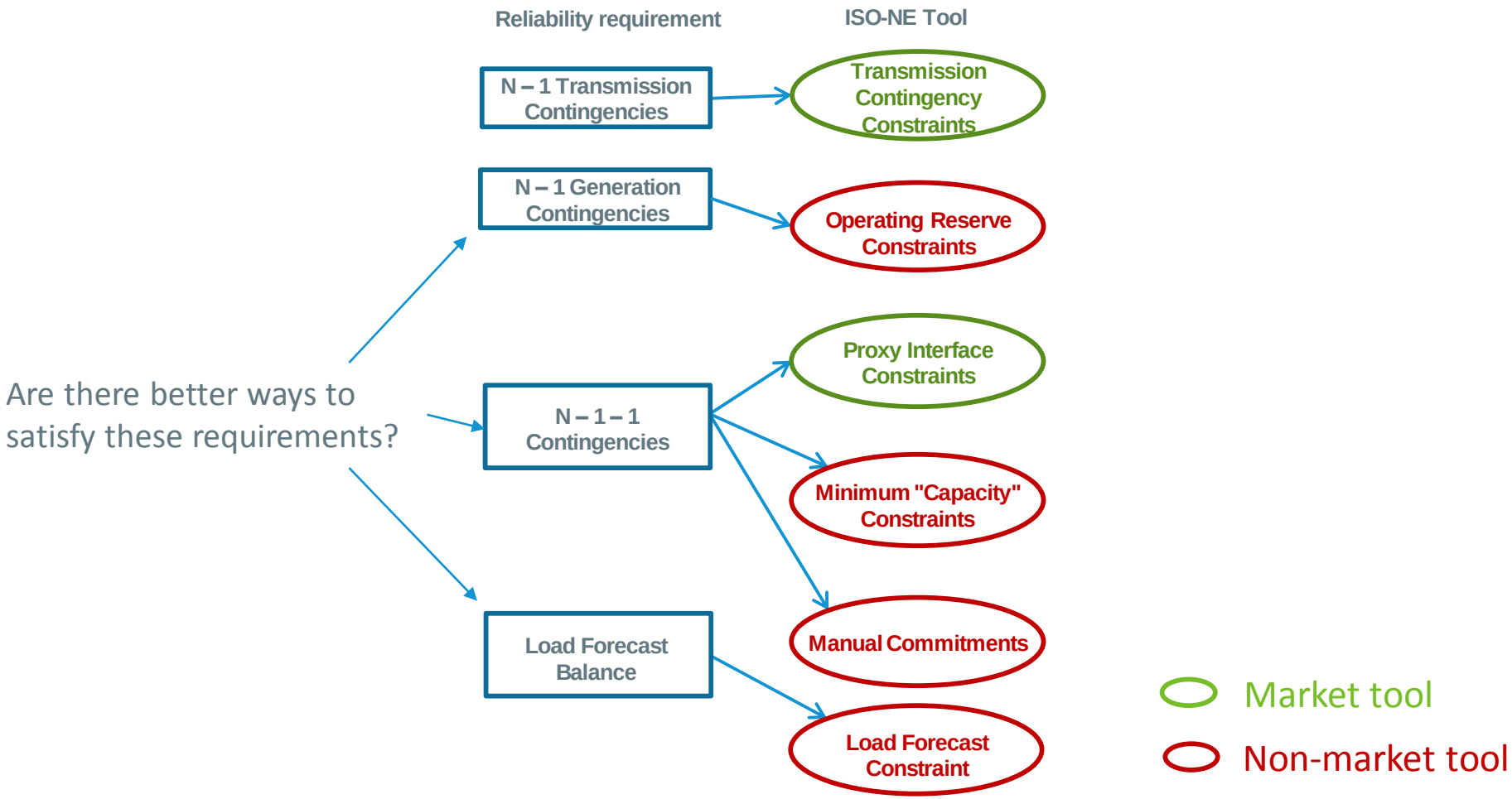
DA Reliability Requirements

- ISO New England's next-day Operating Plan considers the following
  - N – 1 transmission contingencies (NERC FAC-011-3)
  - N – 1 generation contingencies (NERC FAC-011-3)
  - N – 1 – 1 contingencies (NERC IRO-009-2 *and* ISO-NE MLCC-15)
    - Line-line, gen-line, or gen-gen
    - 30-minute recovery time
  - Load forecast balance (NERC TOP-002-4)

Reliability Tools

- ISO New England currently uses six DA reliability tools to meet these DA reliability requirements
  - Transmission contingency constraints
  - Operating reserve constraints
  - Proxy interface constraints
  - Minimum “capacity” constraints (i.e., constraints on energy output)
  - Manual commitments
  - Load forecast constraints
- Each tool can satisfy at least one reliability requirement

DA Reliability Requirements and Tools



Summary of Major Findings from Session 1

- ISO-NE's next-day Operating Plan must satisfy specific next-day reliability requirements
- Three reliability requirements are satisfied through non-market tools – potential areas of improvement:
  - **N-1 generation contingencies**
  - **N-1-1 contingencies**
  - **Load forecast balance**

Motivating Question

- How do other ISOs/RTOs meet these reliability requirements in their day-ahead market and/or DA reliability review processes?
- We will discuss how that works for:
  - NYISO
  - PJM
  - MISO
  - SPP
  - CAISO
  - ERCOT
- The practices of other ISOs/RTOs will be compared to those of ISO New England

Key Takeaways

- All ISOs, except ISO-NE, have one or several **DAM reserve products**, although their product designs vary
- DA reserve products in other ISOs are mostly treated as **forward sales of RT reserves**, except for PJM where the DA reserve is "capacity" type of product with no RT price settlement
- N-1-1 contingencies are local reliability issues; most ISOs **maintain DA N-1-1 security through non-market tools** (not priced)
- ISOs use a non-market **supplemental unit commitment process** to meet the possible gap between DAM cleared load and the forecasted load

CURRENT PRACTICES OF OTHER ISOs

NYISO: N-1 Generation Contingencies

- NYISO clears three reserve products in DAM and RTM: **10-min spinning**, **10-min non-spinning**, and **30-min operating** reserves
- System requirements for three reserve products are defined based on the **largest generation contingency** (0.5x, 1x, 2x)
- Local reserve requirements are modeled
- **No virtuals** are allowed to provide DA reserves

NYISO: N-1 Generation Contingencies (Cont'd)

- NYISO allows **DA reserve offer prices** but not RT reserves offer prices
  - Each type of DA reserve is allowed a separate offer price
- DA reserve offers are subject to **market mitigation**
- Energy and reserves are **co-optimized** in both DAM and RTM
- The DA reserves are settled as **forward sales of RT reserves**
  - Deviations from DA reserve designations in RT are settled at the RT reserve price

NYISO: N-1-1 Contingencies

- NYISO considers second contingency protection with pre-contingency constraints for the NYC area under Local Reliability Rules (LRR)
- The LRR is enforced as a **minimum requirement on the capacity committed in the area**, e.g.,

$$\Sigma(\text{capacity of committed generators in the area}) \geq \text{Req.}$$

- **Requirement** = (Area Load Forecast – Area Import Limit)
- The minimum capacity constraint for the local area is modeled in the DAM's unit commitment process, but not in the DAM's dispatch and pricing processes

NYISO: Load Forecast Requirement

- The DAM is a multi-pass process that includes a physical "**Pass #2**" to ensure sufficient commitments for forecast load
  - Additional units may be committed in Pass #2 to cover the forecast load at minimum commitment cost (similar to ISO-NE's RAA process)
- NYISO **does not conduct an RAA process** following the DAM
  - Plenty of flexible units are available for dispatch in RT
- Not Priced

Comparison to ISO-NE

	N-1 Gen. Contingency	N-1-1 Contingency	Load Forecast
ISO-NE	Reserve constraints in DA commitment process (unpriced)	Proxy interface limits, Minimum committed "capacity" requirement, Manual Commitment	Forecast load constraint in RAA optimization
NYISO	DA reserves (priced and settled as forward sale of RT reserves)	Minimum committed capacity requirement	Forecast Load constraint in Pass #2 of DAM

* Red color indicates non-market tools; green color indicates market tools

PJM: N-1 Generation Contingencies

- PJM models a **30-min reserve product in DAM**, but there is **no corresponding product in RTM**
  - Two reserve products are modeled in RTM (**not in DAM**): 10-min spinning (“Tier 1” & “Tier 2”) and 10-min non-spinning (“NSR”)
- The DA 30-min reserve requirement is based on a **predetermined percentage of the forecasted daily peak load**
- No local reserve requirement is modeled in DAM
- No virtuals are allowed to provide DA reserves

PJM: N-1 Generation Contingencies (Cont'd)

- **DA reserve offer prices** are allowed
- DA reserve offer prices are **not subject to market mitigation**
- Energy and reserves are **co-optimized** in DAM and RTM
- DA reserve settlement is subject to performance criteria

PJM: N-1-1 Contingencies

- Second contingency protection for local areas may be considered in offline reliability studies that determine interface limits and/or manual commitments

PJM: Load Forecast Requirement

- The requirement to meet the forecasted load is modeled in the **Reliability Unit Commitment (RUC)** process, similar to ISO-NE's Reserve Adequacy Analysis (RAA) process, following the DAM
- **No forecasted load is considered in the DAM** process
- Not priced

Comparison to ISO-NE

	N-1 Gen. Contingency	N-1-1 Contingency	Load Forecast
ISO-NE	Reserve constraints in DA commitment process (unpriced)	Proxy interface limits, Minimum committed "capacity" requirement, Manual Commitment	Forecast load constraint in RAA optimization
PJM	DA 30-min reserve (no RT settlement)	Proxy interface limits, Manual Commitment	Forecast load constraint in RUC

* Red color indicates non-market tools; green color indicates market tools

MISO: N-1 Generation Contingencies

- MISO models two contingency reserve products in DAM and RTM: **10-min spinning** and **10-min non-spinning (supplemental) reserves**
  - Currently, there are **no 30-min reserve** products in DAM or RTM
- System requirements for two contingency reserve products are defined based on the **largest generation contingency**
  - ~ 50% of the largest generation is required as 10-min spinning reserve
- **No local reserve** requirements are modeled in DAM
  - **Reserve deployment constraints** are used to ensure reserve deliverability on critical paths
- **No virtuals** are allowed to provide DA reserves

MISO: N-1 Generation Contingencies (Cont'd)

- **Reserve offer prices are allowed in both DAM and RTM**
- Reserve offer prices are **subject to market mitigation**
- Energy and reserves are **co-optimized** in both DAM and RTM
- DA reserves are settled as **forward sales of RT reserves**
  - Deviations from DA reserve designations in RT are settled at the RT reserve price

MISO : N-1-1 Contingencies

- MISO uses three tools to provide second contingency protection for certain local areas
  - **Minimum generation requirement** in the commitment process of DAM and Reliability Assessment Commitment (RAC), i.e., the total committed generation in an area and the import limit should cover the area load forecast and the largest generator output in the area
  - **Minimum number of committed units requirement** in the multi-day RAC or through manual commitment
  - **Reserve deployment constraints** are also used to ensure reserve deliverability on critical paths

MISO : N-1-1 Contingencies (Cont'd)

- The **minimum generation requirement** and the **minimum number of committed units requirement** are only used in commitment process, and therefore not priced
- The **Reserve deployment constraints** are co-optimized and priced
  - This creates zonal reserve clearing prices

MISO : Load Forecast Requirement

- MISO ensures that its commitment can satisfy **forecasted load plus buffer** (e.g., 110% of forecast load), in both
  - **DAM commitment process**, and
  - **Reliability Assessment Commitment (RAC) process** (which is similar to ISO-NE's RAA process)
- These constraints are not priced

Comparison to ISO-NE

	N-1 Gen. Contingency	N-1-1 Contingency	Load Forecast
ISO-NE	Reserve constraints in DA commitment process (unpriced)	Proxy interface limits, Minimum committed "capacity" requirement, Manual Commitment	Forecast load constraint in RAA optimization
MISO	DA reserves (as forward sale of RT reserves)	Minimum generation requirement, Minimum units requirement, Reserve deployment constraints for critical paths	Forecast Load constraint plus buffer in DAM commitment process and RAC,

* Red color indicates non-market tools; green color indicates market tools

SPP: N-1 Generation Contingencies

- SPP models two reserve products in DAM and RTM: **10-min Spinning** and **10-min Non-spinning (Supplemental)**
  - No 30-min reserve product
- System requirements for reserve products are defined based on the **two largest generation contingencies**
  - Requirement of each product is half of (100% largest generation contingency + 50% second largest generation contingency)
- No local reserve requirements are modeled in DAM
- **No virtuals** are allowed to provide DA reserves

SPP: N-1 Generation Contingencies (Cont'd)

- **Reserve offer prices are allowed in both DAM and RTM**
- DA reserve offer prices are subject to **Market mitigation**
- Energy and reserves are **co-optimized** in both DAM and RTM
- DA reserves are settled as **forward sales of RT reserves**
  - RT deviations from DA position are settled at the RT reserve price

SPP: N-1-1 Contingencies

- **No second contingencies are modeled** in the DA processes
- **Interpretation**: DA commitment is expected to provide acceptable post-contingency reliability without explicit N-1-1 type constraints
  - If not, they could be resolved through real-time procedures

SPP: Load Forecast Requirement

- SPP models **hourly load forecast requirements in both**
  - **DAM commitment process**, and
  - **Reliability Unit Commitment (RUC) process** (similar to ISO-NE's RAA)
- The requirement is called Instantaneous Load Capacity Requirement (ILCR)
  - ILCR includes some head room on top of the forecasted load to address intra-hour load variation
- Not priced

Comparison to ISO-NE

	N-1 Gen. Contingency	N-1-1 Contingency	Load Forecast
ISO-NE	Reserve constraints in DA commitment process (unpriced)	Proxy interface limits, Minimum committed "capacity" requirement, Manual Commitment	Forecast load constraint in RAA optimization
SPP	DA reserves (as forward sale of RT reserves)	N/A	Forecast Load constraint in DAM commitment process and RUC

* Red color indicates non-market tools; green color indicates market tools

CAISO: N-1 Generation Contingencies

- CAISO models **10-min spinning** and **10-min non-spinning** in its day-ahead Integrated Forward Market (IFM)
  - IFM serves as CAISO's DAM
- **Incremental 10-min spinning/non-spinning** reserve products are procured in Fifteen-Minute Market (FMM)
  - FMM is similar to ISO-NE's RTM
- System reserve requirements are based on the **most severe single contingency** and **percentage of load/generation**
- **Zonal reserve requirements** are modeled in DAM
- **No virtuals** are allowed to provide DA reserves

CAISO: N-1 Generation Contingencies (Cont'd)

- **Reserve offer prices and quantities** are allowed in IFM
- DA reserve offer prices are not subject to market mitigation but have **offer price cap**
- Energy and reserves are **co-optimized** in IFM and FMM
- The increase of RT reserve from the DA designation is settled at the RT reserve price

CAISO: N-1-1 Contingencies

- CAISO provides **second contingency protection** with pre-contingency constraints
- **Minimum capacity constraints** are used in the pre-contingency dispatch to meet the N-1-1 requirement, i.e.,

$$\Sigma(\text{capacity of committed generators in the area}) \geq \text{Req.}$$

  - After contingency, Exceptional Dispatch ("ED") is used in RT to prepare the system for the next contingency
- **Requirement** = (Area Load Forecast – Import Limit), where the import limit is calculated for the specific N-1-1 scenario

CAISO: N-1-1 Contingencies (Cont'd)

- The minimum capacity requirement constraint for the local area is modeled in the IFM's commitment process and RUC; it is **not** priced
- CAISO initiated a **Contingency Modeling Enhancement** (CME) to replace the minimum capacity constraints with N-1-1 transmission constraints for Line-Line contingencies

CAISO: Load Forecast Requirement

- Currently, CAISO **meets the forecasted load in Residual Unit Commitment (RUC)** following the IFM
- Forecasted load is not modeled in the IFM
  - CAISO considered the idea of introducing new products for meeting the forecasted load in IFM, but is no longer pursuing this
- CAISO has recently proposed flexible ramp products to address load uncertainty (forecast and real-time)
  - http://www.caiso.com/Documents/IssuePaper-StrawProposal-Day-AheadMarketEnhancementsPhase2.pdf

Comparison to ISO-NE

	N-1 Gen. Contingency	N-1-1 Contingency	Load Forecast
ISO-NE	Reserve constraints in DA commitment process (unpriced)	Proxy interface limits, Minimum committed "capacity" requirement, Manual Commitment	Forecast load constraint in RAA optimization
CAISO	DA reserves (with incremental RT reserves)	Minimum capacity requirement	Forecast Load constraint in RUC

* Red color indicates non-market tools; green color indicates market tools

ERCOT: N-1 Generation Contingencies

- ERCOT models two reserve products in DAM: **10-min spinning** and **30-min operating** reserves
- The 10-min spinning requirement is based on the **largest generation contingency**
- The 30-min operating reserve requirement is based on **the load forecast error**
- **No local reserve requirements**
- No virtuals are allowed to provide DA reserves

ERCOT: N-1 Generation Contingencies (Cont'd)

- DA reserve bids include **DA reserve offer prices**
- DA reserve offer prices are **not subject to market mitigation**
- Energy and reserves are **co-optimized in DAM** (not in RTM)
- Although there are no RT reserve products, RT reserve capabilities are measured by telemetry
  - Deviations from DA position is settled at RT LMP adder calculated from Operating Reserve Demand Curves (ORDCs)
- DA reserves are essentially settled as a **forward sale of RT reserve capabilities**

ERCOT: N-1-1 Contingencies

- ERCOT does **not model N-1-1 contingencies** in DAM
- **Interpretation**: the system is expected to provide acceptable post-contingency reliability levels without explicit N-1-1 constraints
  - If not, they could be resolved through real-time procedures

ERCOT: Load Forecast Requirement

- The forecasted load requirement is modeled **in the Reliability Unit Commitment (RUC) process** following the DAM
- Not priced

Comparison to ISO-NE

	N-1 Gen. Contingency	N-1-1 Contingency	Load Forecast
ISO-NE	Reserve constraints in DA commitment process (unpriced)	Proxy interface limits, Minimum committed "capacity" requirement, Manual Commitment	Forecast load constraint in RAA optimization
ERCOT	DA reserves (as forward sale of RT reserve capabilities)	N/A	Forecast Load constraint in RUC

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SUMMARY OF ISO PRACTICES

Summary on DAM Reserve Products

	DA Reserve Products	DA Reserve Requirements	DA Reserve Offer Price?	DA Reserve Mitigation	DA Local Reserves?
ISO-NE	N/A	Largest gen	N/A	N/A	N/A
NYISO	10-min spinning/non-spinning, 30-min operating	Largest gen	Yes	Yes	Yes
PJM	30-min	Percentage of peak load	Yes	Yes	No
MISO	10-min spinning, 10-min non-spinning	Largest gen	Yes	Yes	Deployment constraint
SPP	10-min spin, 10-min supplemental	First and second largest gen	Yes	Yes	No
CAISO	10-min spinning, 10-min non-spinning	Largest contingency or percentage of load/gen	Yes	Price cap	Yes
ERCOT	10-min spinning, 30-min operating	Largest gen and forecast error	Yes	None	No

Average 2017 DA Reserve Clearing Prices in ISOs*

	10-min Spinning	10-min Non-spinning	30-min Reserve
ISO-NE	N/A	N/A	N/A
NYISO	$4.55	$4.01	$4.00
PJM	N/A	N/A	$0.32
MISO	$3.36	$0.98	N/A
SPP	$5.38	$0.76	N/A
CAISO	$1.01	$0.00	N/A
ERCOT	$9.83	N/A	$2.82

* System-wide reserve clearing prices only (not local reserve prices)

Summary on N-1-1 Treatment

	Considered?	In what form?	In which processes?
ISO-NE	Yes	Proxy interface limits, minimum committed "capacity" constraints, manual commitment	DAM, RAA
NYISO	Yes	minimum capacity constraints	DAM Commitment Pass #2
PJM	Yes	Proxy interface limits	DAM, RUC
MISO	Yes	minimum generation requirements, minimum number of generators	DAM commitment process, RAC
SPP	No	N/A	N/A
CAISO	Yes	minimum capacity constraints	DAM commitment process, RUC
ERCOT	No	N/A	N/A

* Red color indicates non-market tools; green color indicates market tools

Summary on Meeting Forecast Load

	Considered?	In what form?	In which processes?
ISO-NE	Yes	Load balance constraint	RAA
NYISO	Yes	Load balance constraint	DAM Pass #2
PJM	Yes	Load balance constraint	RUC
MISO	Yes	Load balance constraint	RAC
SPP	Yes	Load balance constraint	DAM commitment process, RAA
CAISO	Yes	Load balance constraint	RUC
ERCOT	No	Load balance constraint	RUC

KEY TAKEAWAYS

Key Takeaways (Recap)

- All ISOs, except ISO-NE, have one or several **DAM reserve products**, although their product designs vary
- DA reserve products in other ISOs are mostly treated as **forward sales of RT reserves**, except for PJM where the DA reserve is "capacity" type of product with no RT price settlement
- N-1-1 contingencies are local reliability issues; most ISOs **maintain N-1-1 security through non-market tools** (not priced)
- ISOs use a non-market **supplemental unit commitment process** to meet the possible gap between DAM cleared load and the forecasted load

Questions