Synchronized Reserve Overview

David Kimmel
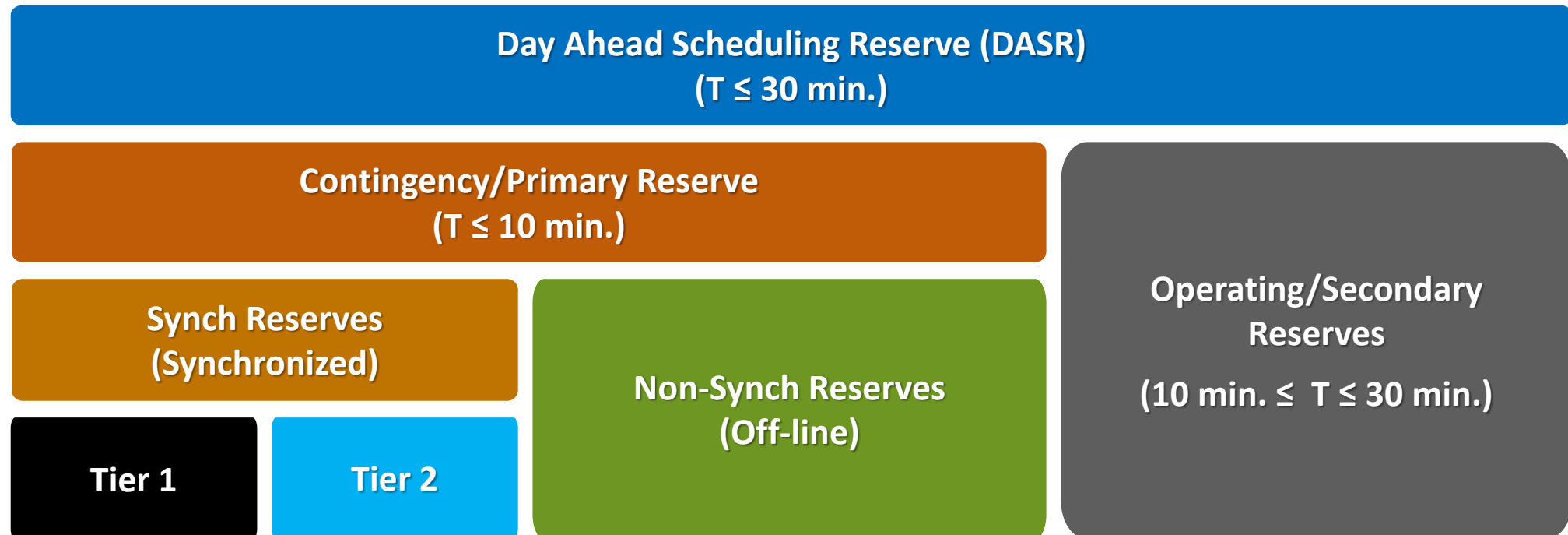
Senior Engineer, Performance Compliance

Synchronized Reserve Deployment Task Force
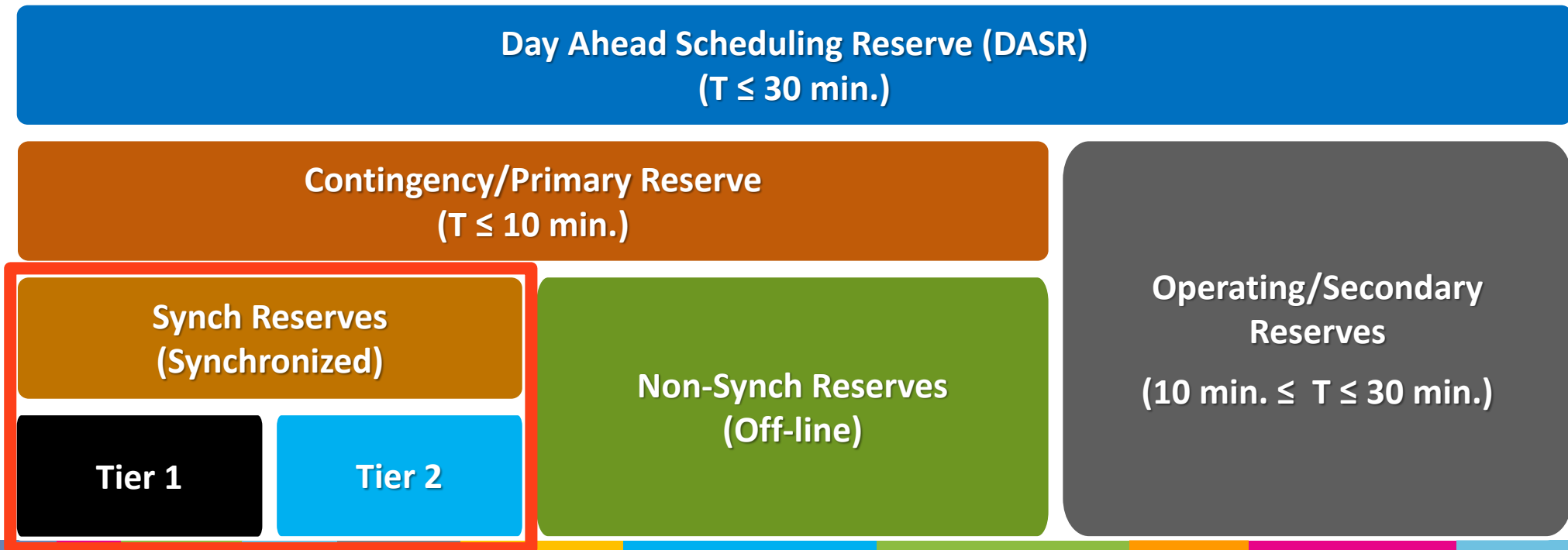
April 30, 2021

What are Reserves?

- Reserves are additional generation capacity above the expected load.

- Protects the power system against the uncertain occurrence of future operating events.

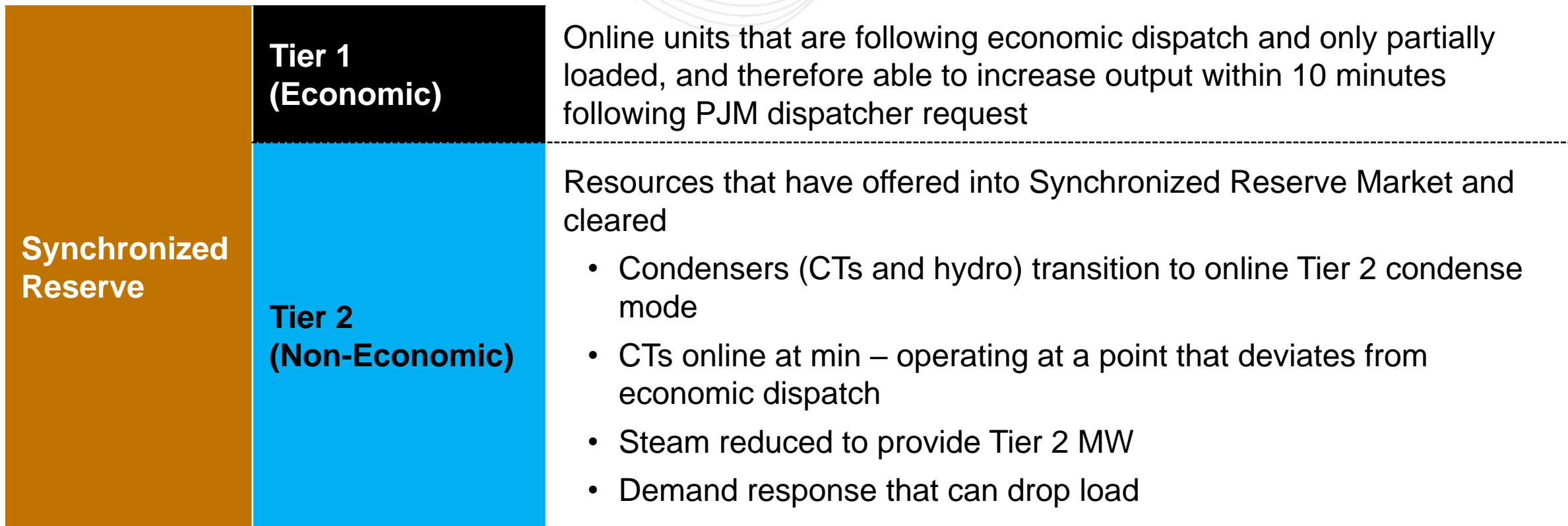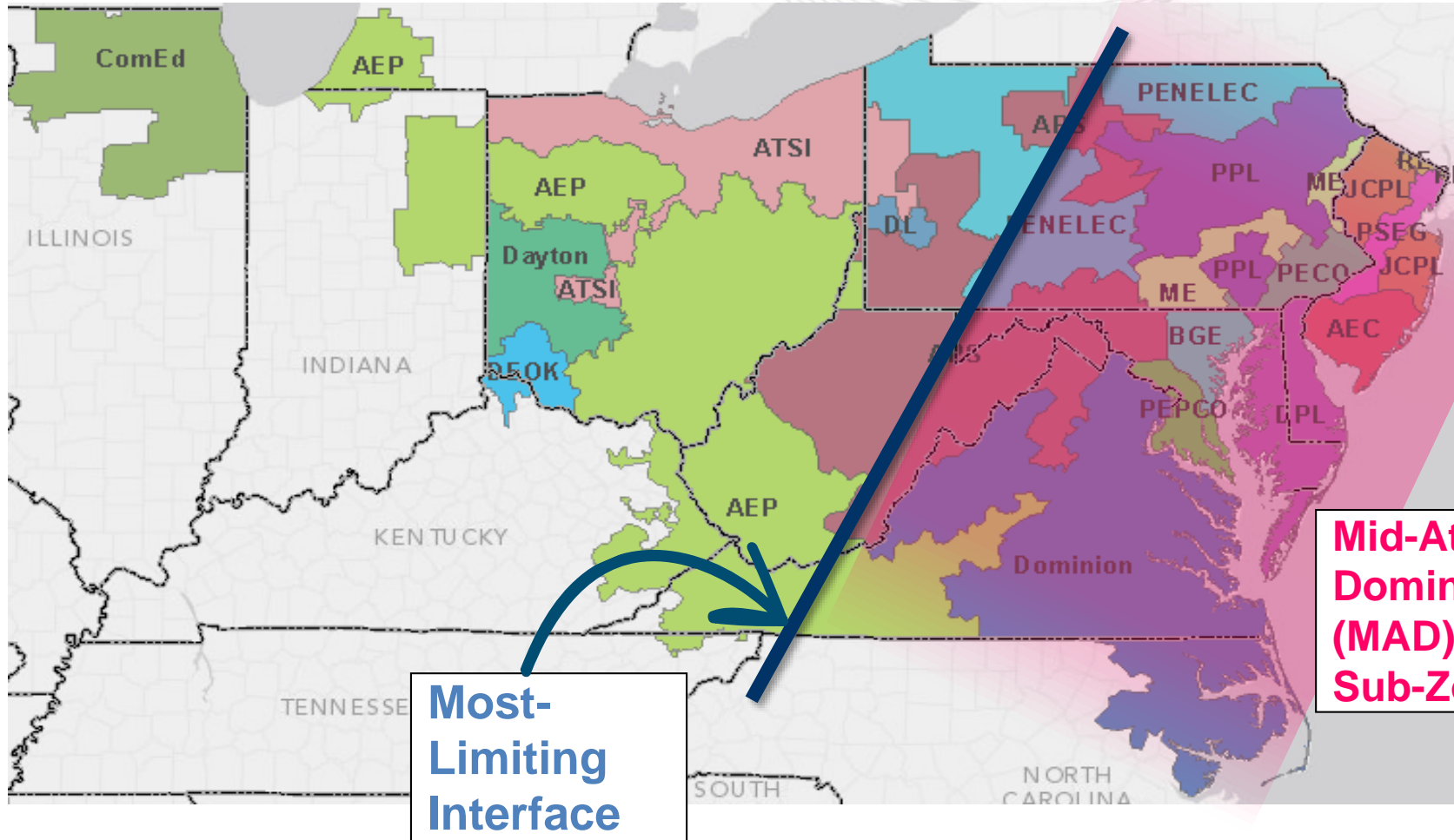| Day Ahead Scheduling Reserve (DASR) (T ≤ 30 min.)		
Contingency/Primary Reserve (T ≤ 10 min.)		**Operating/Secondary Reserves** (10 min. ≤ T ≤ 30 min.)
Synch Reserves (Synchronized)	**Non-Synch Reserves (Off-line)**	
Tier 1 / **Tier 2**		

What are Reserves?

- Reserves are additional generation capacity above the expected load.

- Protects the power system against the uncertain occurrence of future operating events.

Day Ahead Scheduling Reserve (DASR) (T ≤ 30 min.)		
Contingency/Primary Reserve (T ≤ 10 min.)		Operating/Secondary Reserves (10 min. ≤ T ≤ 30 min.)
Synch Reserves (Synchronized)	Non-Synch Reserves (Off-line)	
Tier 1 / Tier 2		

- Loss of a large unit

- Low ACE for an extended period of time

- Shared Reserves called by NPCC, and PJM cannot cover its portion by Regulation alone

- Transfer Interface Overload

- Sudden large loss of energy import from interchange

- Sudden restoration of large Demand

- Reserve capability on units that can be converted fully into energy or load that can be removed from the system within 10 minutes of the request from the PJM dispatcher and must be provided by equipment electrically synchronized to the system

- Includes:

    – Increase in the output of a synchronized generator.

    – Reduction in load from a synchronized resource such as the load of a pumped hydro resource currently synchronized in the pumping mode and capable of being shut down.

    – The maximum output energy level that could be attained on a resource operating as a synchronous condenser.

5

Synchronized Reserve	Tier 1 (Economic)	Online units that are following economic dispatch and only partially loaded, and therefore able to increase output within 10 minutes following PJM dispatcher request
	Tier 2 (Non-Economic)	Resources that have offered into Synchronized Reserve Market and cleared • Condensers (CTs and hydro) transition to online Tier 2 condense mode • CTs online at min – operating at a point that deviates from economic dispatch • Steam reduced to provide Tier 2 MW • Demand response that can drop load

Mid-Atlantic Dominion (MAD) Sub-Zone

Most-Limiting Interface

- Two Reserve Zones
  - RTO Zone covers the entire RTO
  - Mid-Atlantic Dominion (MAD) Zone is a sub-zone due to potential deliverability issues
    - Defined based on most limiting transfer interface

- The Synchronized Reserve Requirement is defined as the amount of 10-minute reserve that must be synchronized to the grid.

- May be met with Tier 1 or Tier 2 resources.

- RTO reserve zone requirement is a dynamic number equal to the sum of:

  – The MW output of the largest online contingency unit(s) in the RTO Synchronized Reserve Zone.

  – An extended requirement of 190 MW.

  – Any additional reserve MW's called on in real-time to cover any operational uncertainty during emergency conditions, hot weather alerts, or cold weather alerts.

- Mid-Atlantic Dominion (MAD) Sub-Zone requirement is a dynamic number equal to the sum of:

  – The MW output of largest online contingency unit(s) in the MAD Synchronized Reserve sub-zone.

  – An extended requirement of 190 MW.

  – Any additional reserve MW's called on in real-time to cover operational uncertainty during emergency conditions, cold weather alerts or hot weather alerts.

A must offer requirement is applied to the Synch Reserve Market.

- Implicit must offer requirements are already built into the design of Tier 1 Synch Reserve and NSR
  - All online generation resources following PJM's dispatch and operating below eco max are automatically considered in the commitment of Tier 1 resources.
  - All available offline generation capable of providing energy within 10 minutes are automatically considered in the commitment of NSR.

- No Three Pivotal Supplier test - already a cost based market.

There is a must offer requirement for Tier 2 Synch Reserve resources.

- All on-line non-emergency capacity resources available to provide energy and capable of providing synchronized reserves must submit offers for Tier 2 Synchronized Reserves.

  - All other non-emergency capacity resources must offer Tier 2 during periods for which PJM has issued a Primary Reserve Warning, Voltage Reduction Warning or Manual Load Dump Warning.

- Penalty for violating the must offer requirement can be referral to the Market Monitor.

- Eligibility
  - "Generation resources, including Energy Storage resources enrolled in the ESR participation model, must be able to provide 0.1 MW of Tier 2 Synchronized Reserve Capability in order to participate in the Tier 2 Synchronized Reserve Market. Demand Resources must be able to provide 0.1 MW of Tier 2 Synchronized Reserve Capability in order to participate in the Tier 2 Synchronized Reserve Market." (Manual 11 – Section 4.2.1)

- Commitment
  - "Any resource that is committed for Tier 2 when a synchronized reserve event occurs is obligated to respond for their commitment at the start of the event within 10 minutes." (Manual 11 – Section 4.2.6)

1) PJM dispatcher determines the approximate amount and location of lost generation, and the amount of Synchronized Reserve that must be loaded to correct for the sudden loss of generation (Reportable Balancing Contingency Event (RBCE)).

   - An RBCE in the Eastern Interconnection is the lesser of 900 MWs or 80 percent of the Most Severe Single Contingency.

2) Implement 100 percent Synchronized Reserves and/or Quick-Start Reserves if there is insufficient regulation and economic generation to recover the ACE within the NERC standards.

3) PJM dispatcher requests the resource owner, via the PJM ALL-CALL, to load a percentage (25, 50, 75, or 100 percent) of the Synchronized Reserve (typically 100 percent) in the appropriate control zone(s).

4) If specific equipment is excluded from the request, the PJM dispatcher calls the appropriate resource owner immediately following the PJM ALL-CALL message.

5) If transmission limits exist, or may be caused by loading Synchronized Reserve in certain geographic areas or control zones, the PJM dispatcher specifies the areas or control zones that are to be included in the request for Synchronized Reserve.

6) If the PJM dispatcher anticipates that loading of Synchronized Reserve may continue for longer than 10 minutes, the PJM dispatcher includes this statement in the PJM ALL-CALL message.

7) The PJM dispatcher contacts external systems to implement shared reserves (as required).

8) PJM dispatcher also requests the loading of an appropriate amount of Non-Synchronized Reserve (as required).

9) If the PJM dispatcher determines that the Synchronized Reserve that is being loaded is not sufficient to recover the system from a facility malfunction or failure, the PJM dispatcher requests Synchronized Supplemental Reserve to be loaded (as required).

10) As the resource owner dispatchers load the reserves, the PJM dispatcher evaluates the effect. The PJM dispatcher surveys the resources loaded and determines generation that is needed to remain loaded and the replacement resources that can be returned to normal status so that the PJM Balancing Authority load can be economically carried at a new price level.

11) The PJM dispatcher cancels the requests, as appropriate.

1) Resource owners that elect to use their assets to respond to an event shall, without regard to price and as quickly as possible, load the requested percentage of Synchronized Reserve and Non-Synchronized Reserve. PJM Members responding to the event will continue to load resources until directed by the PJM dispatcher to discontinue. Resources providing Regulation service should only provide Synchronized Reserves to the extent that they can quickly resume accurate Regulation control following the event.

2) Upon cancellation, the Generation Owner dispatchers unload the Synchronized and Non-Synchronized Reserve, as directed by the PJM dispatcher.

- Resource responses are verified by the PJM Performance Compliance department following each event.

- Actual responses compared to assignments during the synchronized reserve event are used to determine penalties.

- Resource response to a synchronized reserve event is the difference between the resource's output at the start of the event and its output ten minutes after the start of the event allowing for small fluctuations and possible telemetry delays

- Resource output <u>at the start of</u> the event

  - The **_lowest_** telemetered output between 1 minute prior to and 1 minute following the start of the event

1 Minute   **Event Start**   **1 Minute**

Resource Output

- Resource output <u>ten minutes after</u> the event

  - The **_greatest_** output achieved between 9 and 11 minutes after the start of the event

  - Unit reduction after 10 minute mark before end of event will decrease total response

Event Start   **9-11 Minutes**

Resource Output
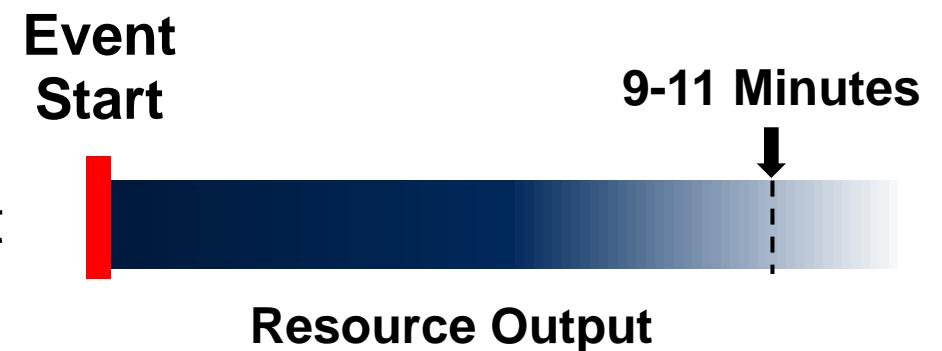
		Event Start					Event End		
Minute	-1	1	2	3	4	5	6	7	8
Unit Output (MW)	3	4	5	6	5	4	5	6	6
Credited Response (MW)	-	3	3	3	3	3	3	-	-

- Event lasting 5 minutes
  - Unit's Tier 1:
    - Calculated response:
      - Maximum of minutes (5 to 7) - minimum of minutes (-1 to 2)
      - Max (5, 6, 7) - min (3, 4, 5) = 6 - 3 = 3 MW
  - Unit's Tier 2:
    - Response is equal to assignment for event less than or equal to 10 minutes
    - Assignment = 4 MW
    - Response = 4 MW

		Event Start								Ten Minutes				Event End	
Minute	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Unit Output (MW)	103	104	105	106	105	104	105	106	106	106	104	103	106	102	109
Credited Response (MW)	-	3	3	3	3	3	3	3	3	3	3	0	3	-1	-

- For events lasting longer than ten minutes:
  - If the unit outputs more energy at minutes beyond ten, the unit's response is capped at its ten minute response.
  - If the unit outputs less energy at minutes beyond ten, the unit's response is reduced by that MW amount.

- Unit's Tier 1 MW

a. Calculate Initial MW

  i. Minimum of minutes (-1, 1, 2) = Minimum(103, 104, 105) = 103 MW

b. Calculate Response at Minute 10

  i. Maximum of minutes (9, 10, 11) = Maximum(106, 104, 103) = 106 MW

c. Calculate Response for minutes 1 to 10

  i. b.i. - a.i. = 106 - 103 = 3 MW

d. Calculate Response at Minutes ≥ 11

  i. Response of minute 11 = minimum of (c.i.) or (103 - 103) = minimum of (3) or (0) = 0 MW

  ii. Response of minute 12 = minimum of (c.i.) or (106 - 103) = minimum of (3) or (3) = 3 MW

  iii. Response of minute 13 = minimum of (c.i.) or (102 - 103) = minimum of (3) or (-1) = -1 MW

e. Calculate Total Response

  - Sum of minutes (1 to 13) divided by length of minutes (1 to 13)

  - (3+3+3+3+3+3+3+3+3+3+0+3+(-1)) / 13 minutes = 32 / 13 = 2.4615 MW

- Unit's Tier 2 MW

  a. Assignment is 4 MW

  b. Calculate Initial MW

    i. Minimum of minutes (-1, 1, 2) = Minimum(103, 104, 105) = 103 MW

  c. Calculate Response at Minute 10

    i. Maximum of minutes (9, 10, 11) = Maximum(106, 104, 103) = 106 MW

  d. Calculate Response for minutes 1 to 10

    i. b.i. - a.i. = 106 - 103 = 3 MW

  e. Calculate Response at Minutes ≥ 11

    i. Response of minute 11 = minimum of (c.i.) or (103 - 103) = minimum of (3) or (0) = 0 MW

    ii. Response of minute 12 = minimum of (c.i.) or (106 - 103) = minimum of (3) or (3) = 3 MW

    iii. Response of minute 13 = minimum of (c.i.) or (102 - 103) = minimum of (3) or (-1) = -1 MW

  f. Calculate Total Response

    - Assignment - (Sum of minutes (1 to 13) divided by length of minutes (1 to 13))

    - 4 – ((3+3+3+3+3+3+3+3+3+3+0+3+(-1)) / 13 minutes) = 4 - (32 / 13) = 1.5385 MW shortfall

		Event Start								Ten Minutes				Event End	
Minute	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Unit Output (MW)	103	104	105	106	105	104	105	106	106	106	104	108	110	115	109
Credited Response (MW)	-	5	5	5	5	5	5	5	5	5	5	5	5	5	-

- For events lasting longer than ten minutes:
  - If the unit outputs more energy at minutes beyond ten, the unit's response is capped at its ten minute response.
  - If the unit outputs less energy at minutes beyond ten, the unit's response is reduced by that MW amount.

- Unit's Tier 1 MW

  a. Calculate Initial MW

     i. Minimum of minutes (-1, 1, 2) = Minimum(103, 104, 105) = 103 MW

  b. Calculate Response at Minute 10

     i. Maximum of minutes (9, 10, 11) = Maximum(106, 104, 108) = 108 MW

  c. Calculate Response for minutes 1 to 10

     i. b.i. - a.i. = 108 - 103 = 5 MW

  d. Calculate Response at Minutes ≥ 11

     i. Response of minute 11 = minimum of (c.i.) or (108 - 103) = minimum of (5) or (5) = 5 MW

     ii. Response of minute 12 = minimum of (c.i.) or (110 - 103) = minimum of (5) or (7) = 5 MW

     iii. Response of minute 13 = minimum of (c.i.) or (115 - 103) = minimum of (5) or (12) = 5 MW

  e. Calculate Total Response

     • Sum of minutes (1 to 13) divided by length of minutes (1 to 13)

     • (5+5+5+5+5+5+5+5+5+5+5+5+5) / 13 minutes = 65 / 13 = 5 MW

- Unit's Tier 2 MW

a. Assignment is 4 MW

b. Calculate Initial MW

  i. Minimum of minutes (-1, 1, 2) = Minimum(103, 104, 105) = 103 MW

c. Calculate Response at Minute 10

  i. Maximum of minutes (9, 10, 11) = Maximum(106, 104, 108) = 108 MW

d. Calculate Response for minutes 1 to 10

  i. b.i. - a.i. = 108 - 103 = 5 MW

e. Calculate Response at Minutes ≥ 11

  i. Response of minute 11 = minimum of (c.i.) or (108 - 103) = minimum of (5) or (5) = 5 MW

  ii. Response of minute 12 = minimum of (c.i.) or (110 - 103) = minimum of (5) or (7) = 5 MW

  iii. Response of minute 13 = minimum of (c.i.) or (115 - 103) = minimum of (5) or (12) = 5 MW

f. Calculate Total Response

  - Assignment - (Sum of minutes (1 to 13) divided by length of minutes (1 to 13))

  - 4 – ((5+5+5+5+5+5+5+5+5+5+5+5+5) / 13 minutes) = 4 - (65 / 13) = 1 MW surplus

- A unit's response can be converted from MW to MWh by multiplying the MW calculated by the length (minutes) of the event divided by 60 minutes.

- Examples:
  - From event lasting 5 minutes:
    - Calculated MW response = 3 MW
    - (3) x (5 / 60) = 0.25 MWh response
  - Conversely, MWh can be converted to MW by multiplying the MWh by 60 minutes divided by the length (minutes) of the event.

- Can units currently assigned regulation provide Synchronized Reserve Tier 1 response?

  – Yes.

- Will units currently assigned regulation that also provide Synchronized Reserve Tier 1 response be eligible for compensation?

  – Yes. These units will receive Tier 1 compensation based on their response output minus their regulation assignment.

- What happens to the unit's regulation performance score if it provides Synchronized Reserve Tier 1 response?

  – Units that are assigned regulation and provide Synchronized Reserve Tier 1 response during an RBCE will have their regulation performance scores set to null during that time and for up to ten minutes after the event ends. These units are expected to return to their regulating band within ten minutes after the event ends.

- NERC BAL-002-3 (https://www.nerc.com/pa/Stand/Reliability%20Standards/BAL-002-3.pdf)

- NERC Operating Reserve Management Guideline (https://www.nerc.com/comm/RSTC_Reliability_Guidelines/Operating_Reserve_Management_Guideline_V3_Final.pdf)

- PJM Manual 11 (https://www.pjm.com/-/media/documents/manuals/m11.ashx)

- PJM Manual 12 (https://www.pjm.com/-/media/documents/manuals/m12.ashx)

- PJM Manual 13 (https://www.pjm.com/-/media/documents/manuals/m13.ashx)

- Quarterly Synchronized Reserve Performance Update presented to Operating Committee (https://www.pjm.com/committees-and-groups/committees/oc)

SME/Presenter:
David Kimmel,
David.Kimmel@pjm.com

Synchronized Reserve Overview

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com