Reserve Price Formation: Implementation

June 21, 2022

Special Session of the Market Implementation Committee

Overview

- Market Design Change Refresher
- Calculations: Part 1
  - Day-ahead Reserve Clearing Credit
  - Balancing Reserve Clearing Credit
  - Reserve Clearing Charge
- Calculations: Part 2
  - Market Revenue Neutrality Offset
  - Opportunity Cost Credits Owed
- Calculations: Part 3
  - Lost Opportunity Cost Credit
  - Lost Opportunity Cost Charge
- Q/A

Disclaimer

PJM has made all efforts possible to accurately document all information in this presentation. The information seen here does not supersede the PJM Operating Agreement or the PJM Tariff or any pending FERC Filings or Orders.

Overview

Effective October 1, 2022 several aspects to the PJM Reserves market will change

Result of Reserve Price Formation efforts, 2018 to-date

The intent of this special session is to:	Refresh understanding of new terminology and concepts
	Ensure awareness of business rule changes and impacts
	Create opportunity for clarifying questions

Informing Manual language is not part of this session – will be presented through normal process beginning in July

Overview

Markets Gateway changes are not part of this session

- Changes presented at a Tech Change Forum Special Session – New Reserve Market Changes on 5/13/2022

  https://pjm.com/-/media/committees-groups/forums/tech-change/2022/20220513-special/20220513-reserve-price-formation-markets-gateway-education.ashx

Market Design changes are not part of this session

- Changes presented at a Market Implementation Committee Special Session – Reserve Price Formation on 5/27/2022

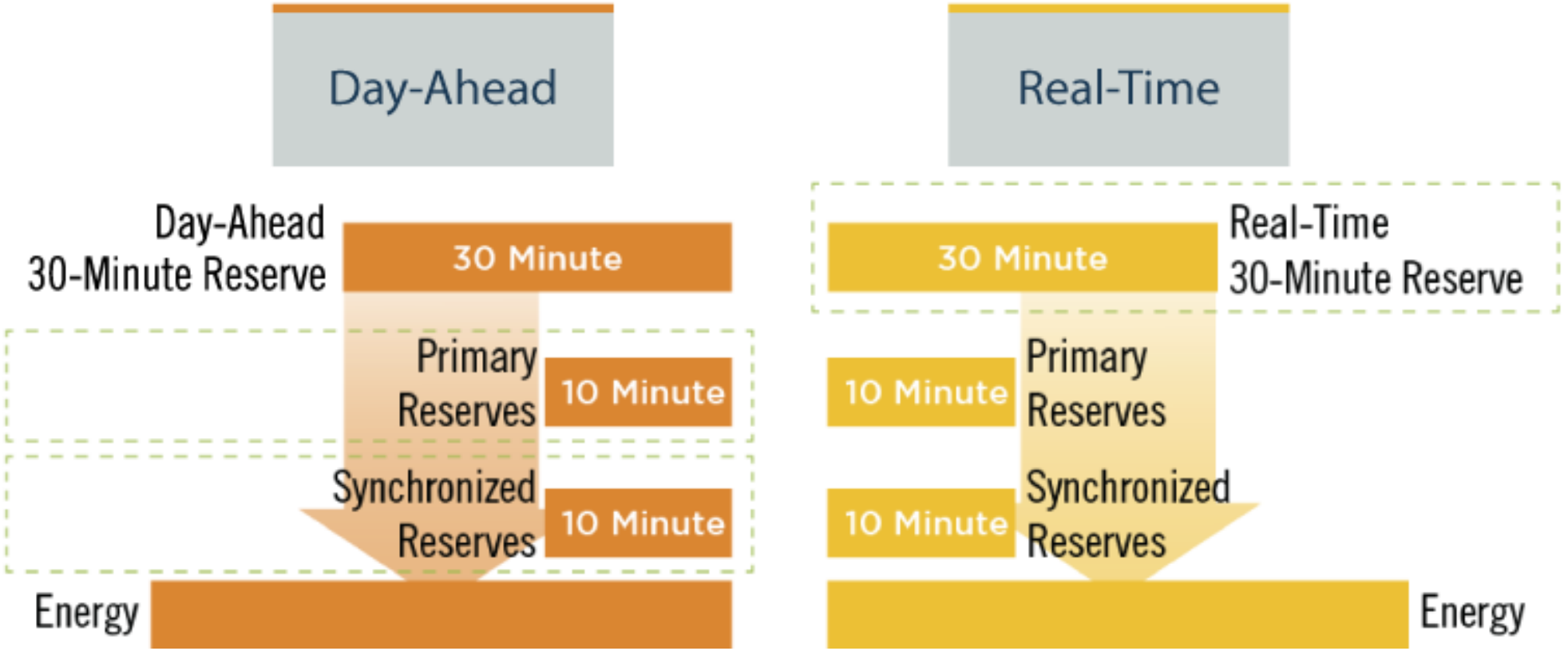
  https://www.pjm.com/-/media/committees-groups/committees/mic/2022/20220527-special-session/item-1---reserve-price-formation-implementation---education.ashx

Acronyms

- BAL = Balancing
- DA = Day-ahead
- LOC = Lost Opportunity Cost
- NSR = Non-Synchronized Reserve
- NSRMCP = Non-Synchronized Reserve Market Clearing Price
- RT = Real-time
- SecR = Secondary Reserve
- SecRMCP = Secondary Reserve Market Clearing Price
- SR = Synchronized Reserve
- SRMCP = Synchronized Reserve Market Clearing Price

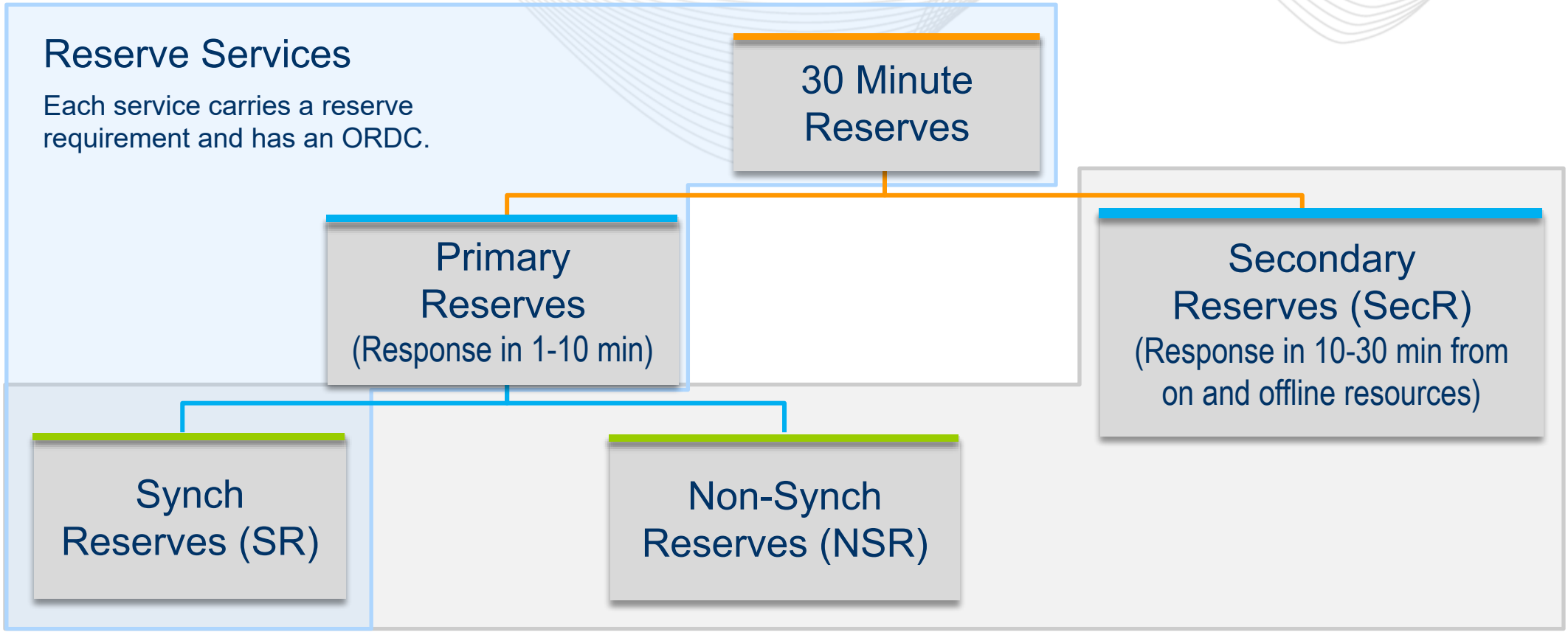
Market Design Changes

Day-Ahead and Real-Time Reserve Alignment



Solidify financial incentives to provide reserves when assigned due to day-ahead financial commitment.
Remove modeling differences between Day-Ahead and Real-Time Energy Markets.

Reserve Services and Products



Clearing Price represents procurement of the Synch Reserve requirement	Clearing price represents procurement of the balance of the Primary Reserve Requirement not met by Synch Reserves	Clearing price represents procurement of the balance of the 30 Min Requirement not met by Synch and Non-Synch Reserves

Tier 1 and Tier 2 reserve products will be consolidated into one, uniform, Synchronized Reserve product that is similar to Tier 2 today

This unified product will:

- Be obligated to respond to PJM instructions during a Synchronized Reserve Event
- Be compensated at the applicable clearing price for the assigned MW amount
- Face the existing penalty if the resource does not respond during an event

This proposed change is motivated by the need to enhance the accuracy of PJM's reserve measurements and the reliability of response in addition to creating comparable compensation for comparable service.

Calculations Part 1:
Day-ahead Reserve Clearing Credit
Balancing Reserve Clearing Credit
Reserve Clearing Charge

Example Resource Details

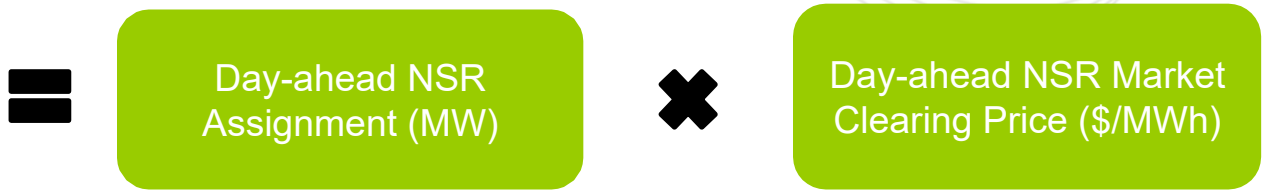
Zone = RTO	Example 1		Example 2	
	Day-ahead	Real-time	Day-ahead	Real-time
Eco Max (MWh)	350	350	350	350
Energy (MWh)	300	325	285	315
LMP ($/MWh)	$40.00	$50.00	$40.00	$50.00
SR Max (MWh)	350	350	350	350
SR MW (MWh)	50	25	50	25
SRMCP ($/MWh)	$15.00	$25.00	$15.00	$25.00
SecR MW (MWh)	0	0	15	10
SecRMCP ($/MWh)	$10.00	$9.00	$10.00	$9.00
NSR MW (MWh)	0	0	0	0
NSRMCP ($/MWh)	$5.00	$6.00	$5.00	$6.00

Clearing Credit and Charge Summary

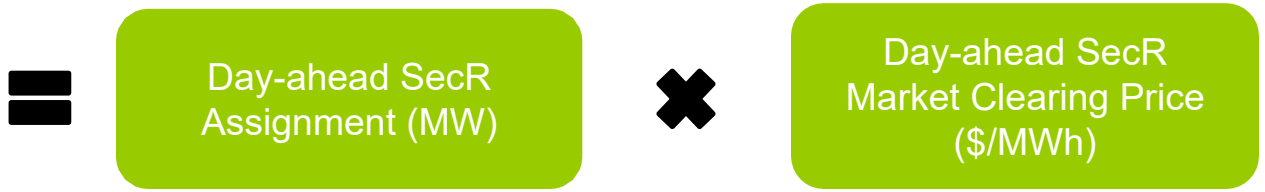
- Each calculation is applied to the RTO Zone and Sub-Zone (if active) independently
- Day-ahead Assignments are flat profiled into 5-minute intervals for use in the Balancing calculations
  - Methodology established with the implementation of 5-minute intervals
- Like energy, Day-ahead will settle hourly and Balancing will settle in 5-minute intervals

Day-ahead Reserve Clearing Credit

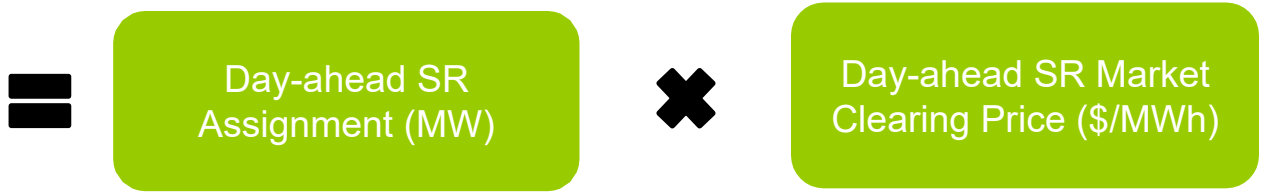
- Non-Synchronized (hourly)



- Secondary (hourly)



- Synchronized (hourly)



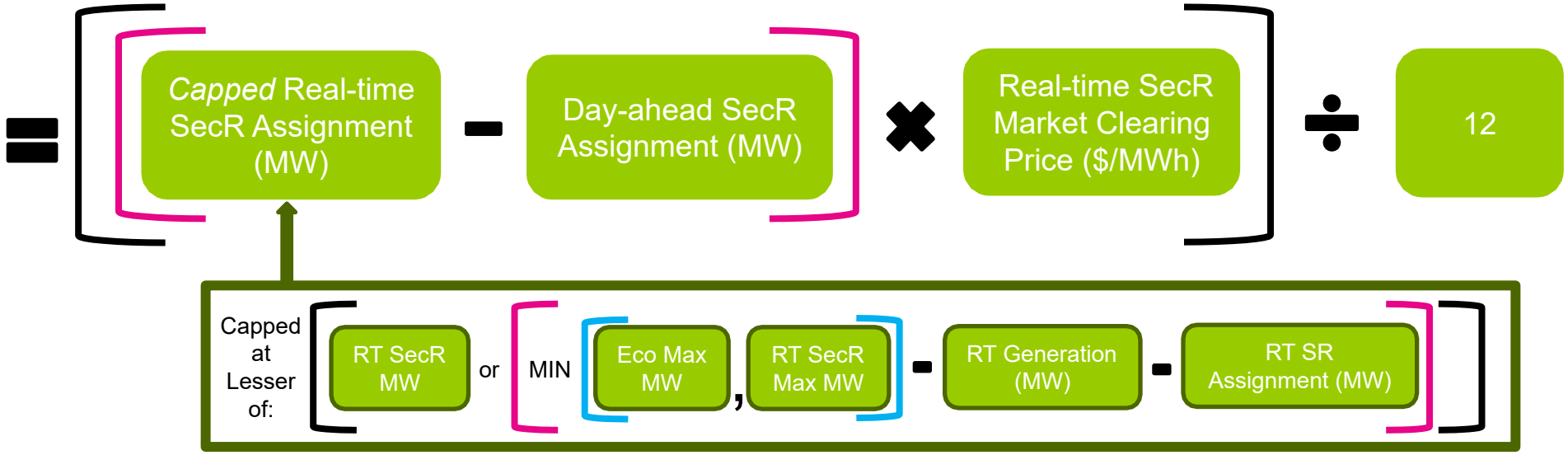
Day-Ahead Reserve Clearing Credit Example

- Example 1:
  - SR Credit = (50 MW * $15.00) = $750.00
- Example 2:
  - SecR Credit = (15 MW * $10.00) = $150.00
  - SR Credit = (50 MW * $15.00) = $750.00

Balancing Reserve Clearing Credit

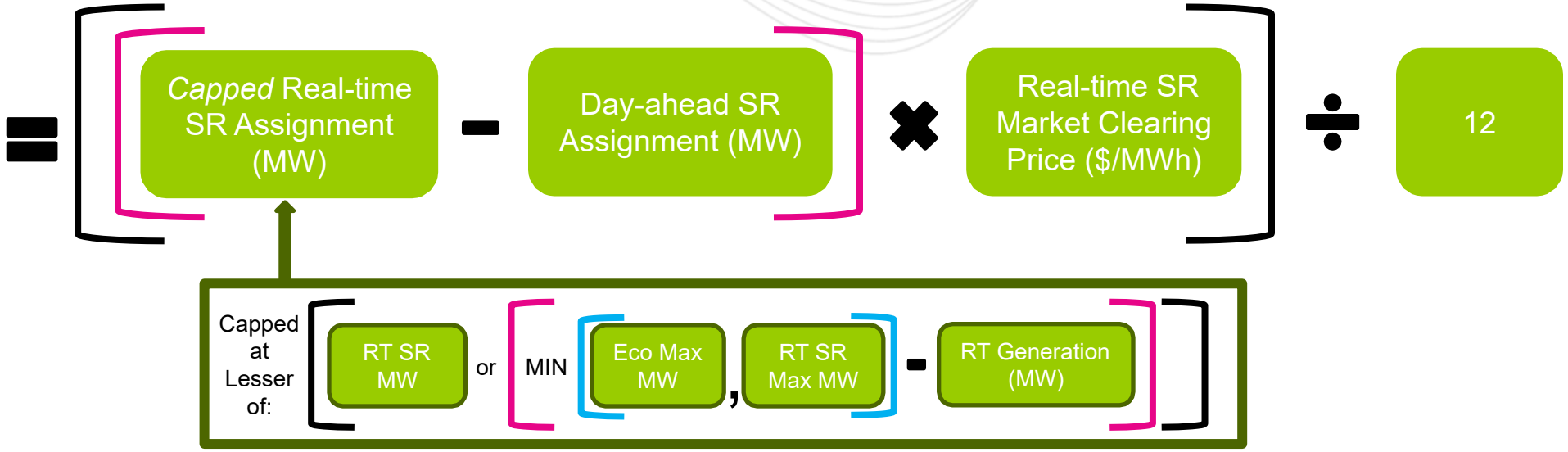
- Non-Synchronized (5-min Interval)

- Secondary (5-min Interval)



Balancing Reserve Clearing Credit

- Synchronized (5-min Interval)

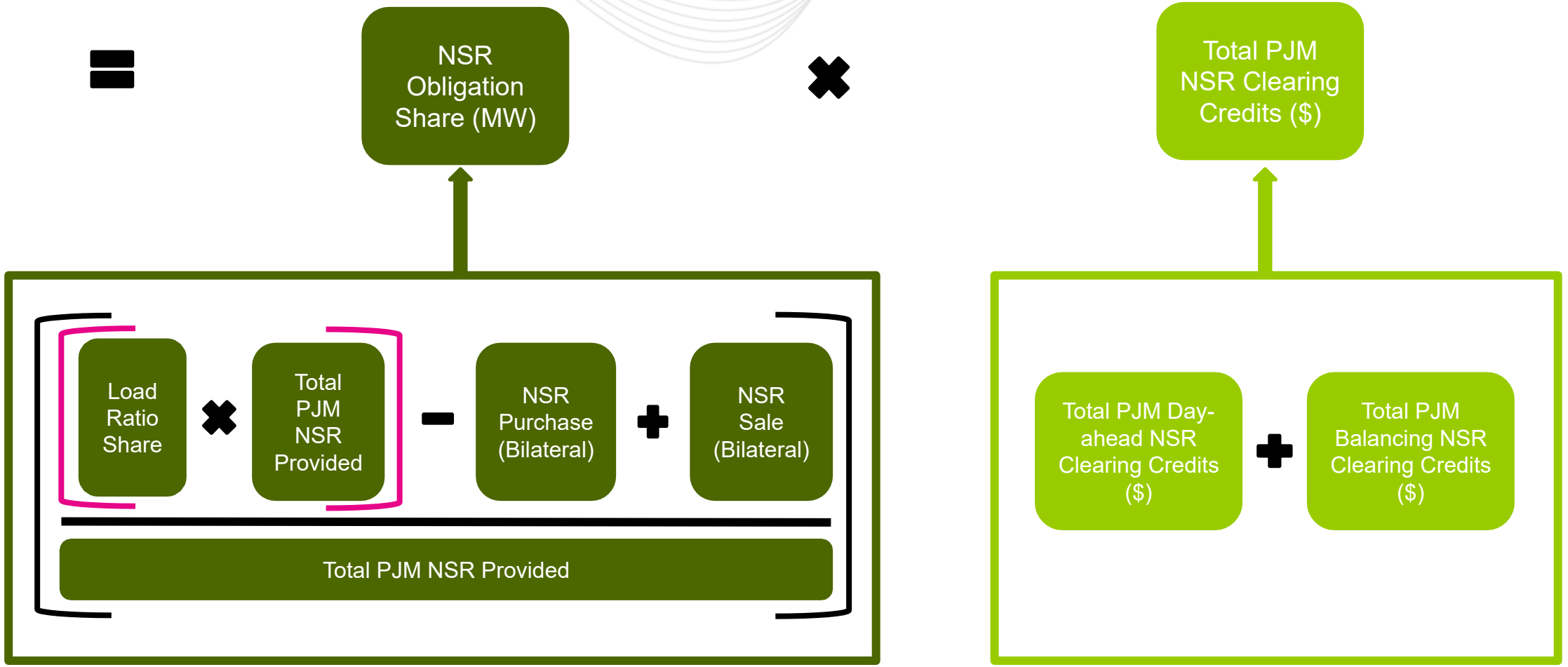


Balancing Reserve Clearing Credit Example

- Example 1:
  - SR Credit = (Min((25 or (Min(350,350) – 325)) – 50)
    = ((25 – 50) * $25.00) / 12 = $(52.08)
- Example 2:
  - SecR Credit = (Min((10 or (Min(350,350) – 315 – 25)) – 15)
    = ((10 – 15) * $9.00) /12 = $(3.75)
  - SR Credit = (Min((25 or (Min(350,350) – 315)) – 50) * $25.00) /12
    = ((25 – 50) * $25.00) / 12 = $(52.08)

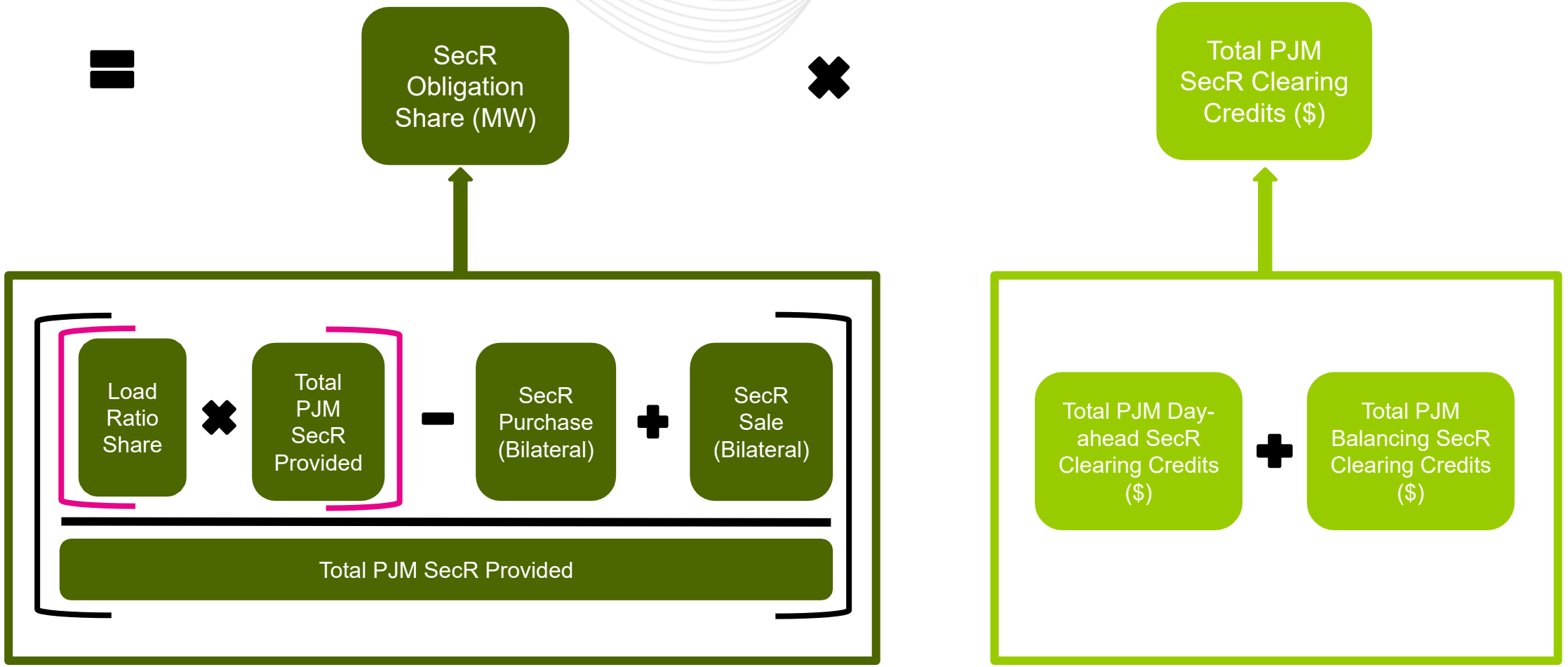
Reserve Clearing Charge

- Non-Synchronized (hourly)



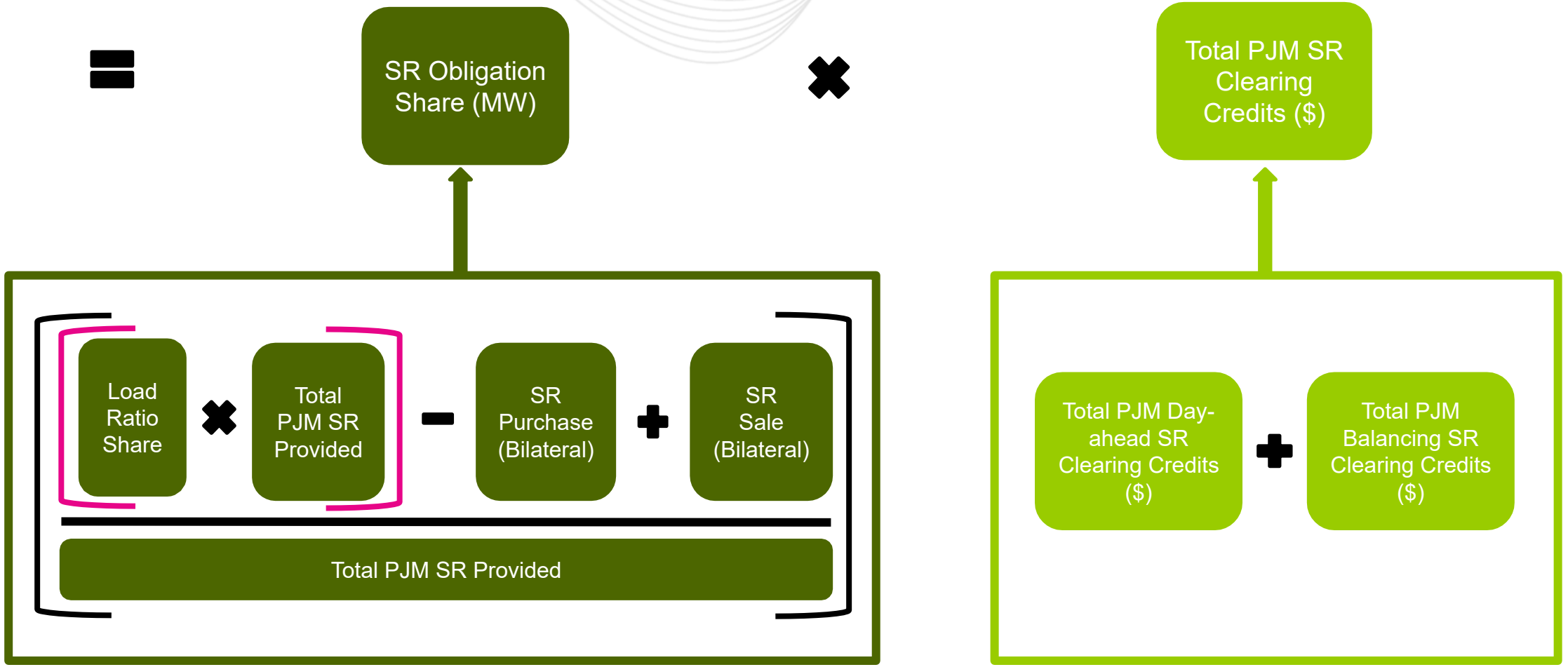
Reserve Clearing Charge

- Secondary (hourly)



Reserve Clearing Charge

- Synchronized (hourly)



Reserve Clearing Charge Example

- Example 1:
  - Load Ratio Share for Member A = 10%
  - Total PJM SR Provided = 250 MW (value created for this example)
  - Total SR Credits for one hour = $1,000 (value created for this example)
    - SR Obligation Share = ((10% * 250) – 0 – 0) / 250 = 0.1 MW
    - SR Charge = 0.1 * $1,000 = $100

Reserve Clearing Charge Example

- Example 2:
  - Load Ratio Share for Member A = 10%
  - Total PJM SR Provided = 250 MW (value created for this example)
  - Total SR Credits for one hour = $1,000 (value created for this example)
    - SR Obligation Share = ((10% * 250) – 0 – 0) / 250 = 0.1 MW
    - SR Charge = 0.1 * $1,000 = $100
  - Total PJM SecR Provided = 100 MW (value created for this example)
  - Total SecR Credits for one hour = $750 (value created for this example)
    - SecR Obligation Share = ((10% * 100) – 0 – 0) / 100 = 0.1 MW
    - SecR Charge = 0.1 * $750 = $75

Retroactive Penalty Charge

- Assessed after an Event and determine if the resource provided the assigned or self-scheduled MW as expected
- Calculated as a charge and reduces the overall credits to be allocated
- Charge calculation utilizes the Real-time Market Clearing Price

Calculations Part 2:
Market Revenue Neutrality Offset
Opportunity Cost Credits Owed

Lost Opportunity Cost Credit

- Co-optimizing energy and reserves in both Day-ahead and Real-time allows PJM to dispatch most appropriate MWs at the least cost to consumers.
- As part of ER19-1486, PJM requested inclusion of two different calculations as part of the Lost Opportunity Cost credit calculation to ensure that resources continue to be made whole to costs, while accounting for the profit earned to offset any losses with the assignment changes
- Two calculations to help ensure proper payment is made in the Lost Opportunity Cost Credit calculation are:
  - Market Revenue Neutrality Offset
  - Opportunity Cost Credits Owed

Market Revenue Neutrality Offset

- Represents the revenue above cost that the resource earned across the energy and reserve markets as a result of change in its assignment between Day-ahead and Real-time
  - Increased energy revenue above cost will offset the decreased reserve buy back dollar value
  - Capped at the opportunity costs owed to each reserve product
- Calculation is not reserve product specific and applies a ratio share offset to all reserve products that were decreased
- This Offset requires certain aspects to have occurred for a resource
  - Must have a Day-ahead reserve assignment
  - Must be asked to reduced its Real-time reserve MW
  - Must be asked to increase Real-time energy
- Example 1 and Example 2 both meet this criteria

Market Revenue Neutrality Offset Ineligibility

- If any of the following occur, then Resource is not eligible for the Offset:
  - Resources' Real-time assignment decreases due to being self-scheduled to provided energy, Regulation or another reserve product
  - Resource reduces its flexibility in Real-time such that it no longer qualifies for that Reserve product in Real-time
  - Resource's Final Offer is less than its Committed Offer
  - Resource trips offline or becomes unavailable in Real-time
  - Resource does not follow dispatch
  - Resource fails to come online and reach Eco. Min within 30 min (SecR only)
  - Resource increases SR offer price between the Real-time and Day-ahead Synchronized Reserve Markets (SR only)

Market Revenue Neutrality Offset Example

- Example 1: (5-min interval)
  - Bal Energy Revenue = (325 – 300) * $50.00 = $1,250 (Increased RT MW)
  - Bal Energy Cost = (325 – 300) * $25.00 = $625 ($25.00 value created for example)
  - Bal Energy Revenue above Cost = ($1,250 - $625) = $625
    - Market Revenue Neutrality Offset = $625
  - Only one reserve market assignment changed
    - 100% of the Market Revenue Neutrality Offset will be included in the SR Lost Opportunity Cost Credit (on slide 36)

Market Revenue Neutrality Offset Example

- Example 2: (5-min interval)
  - Bal Energy Revenue = (315 – 285) * $50.00 = $1,500 (Increased RT MW)
  - Bal Energy Cost = (315 – 285) * $25.00 = $750 ($25.00 value created for example)
  - Bal Energy Revenue above Cost = ($1,500 - $750) = $750
    - Market Revenue Neutrality Offset = $750
  - Two reserve product assignments changed
    - Ratio share of Market Revenue Neutrality Offset in each reserve product to be included in the respective Lost Opportunity Cost Credit
      - For SR: 83.89% or $629.19, but capped at $624.96 (on slide 38)
      - For SecR: 16.11% or $120.81, but capped at $120.00 (on slide 37)

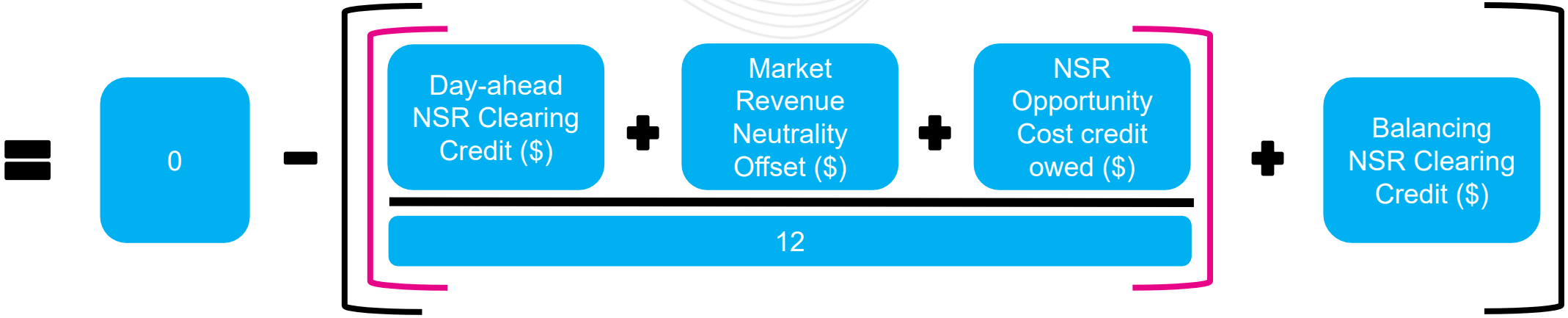
Opportunity Cost Credits Owed

- Calculation applies only when resource is ineligible for Market Revenue Neutrality Offset and a Lost Opportunity Cost Credit has been calculated
- Calculation determines the Opportunity Cost that would have been owed and offsets the buyback associated with decrease real-time reserve MW
- Continues to ensure that resources are made whole to costs and still offsetting any profit earned with assignment change losses

Calculations Part 3:
Lost Opportunity Cost Credit
Lost Opportunity Cost Charge

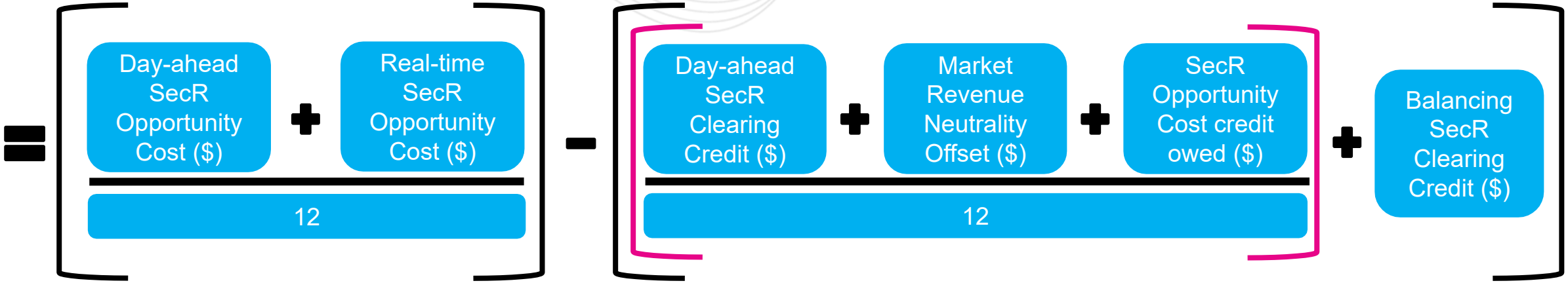
Reserve Lost Opportunity Cost Credit

- Non-Synchronized (5-min Interval)



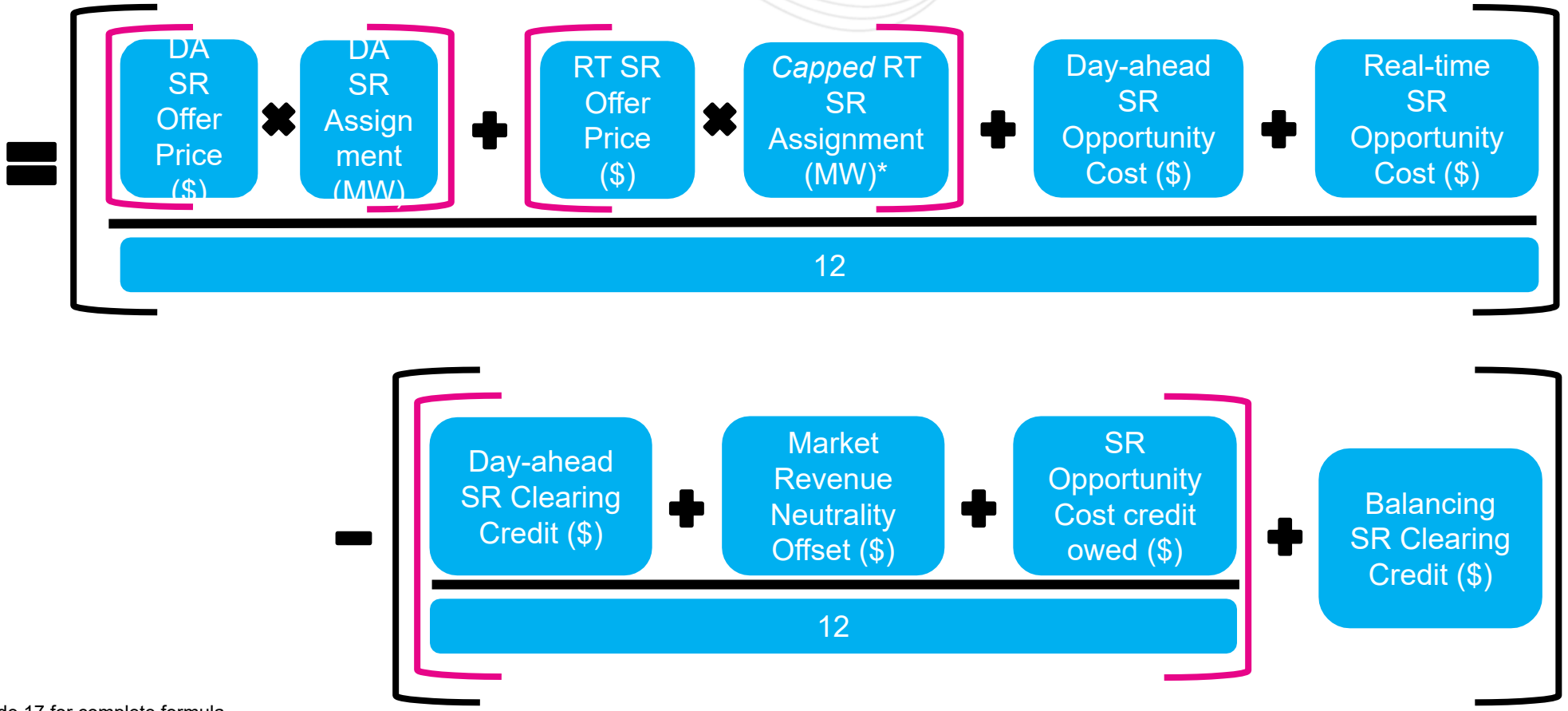
Reserve Lost Opportunity Cost Credit

- Secondary (5-min Interval)



Reserve Lost Opportunity Cost Credit

- Synchronized (5-min Interval)



*See Slide 17 for complete formula

Reserve Lost Opportunity Cost Credit Example

- Example 1: (5-min interval)
  - DA Offer = $0 * 50 = $0
    - DA Offer Price = $0 ($0 value created for example)
    - DA MW = 50
  - RT Offer = $0 * 50 = $0
    - RT Offer Price = $0 ($0 value created for example)
    - Capped RT MW = 25
  - DA Opportunity Cost = (40 – 25) * (350 – 300) = $750
    - DA LMP = $40
    - Energy Cost = $25 ($25 value created for example)
    - DA Energy produced = 300
    - Eco Max = 350
  - RT Opportunity Cost = $0
    - Resource was assigned less MW in RT
  - DA Clearing credit = $750 (from slide 15)
  - Market Revenue Neutrality Offset = $625 (from slide 29)
  - Opportunity Cost Owed = N/A
  - Bal Clearing credit = $(52.08) (from slide 18)

= ((0 + 0 + 750 + 0) / 12) – (((750 + 625 + N/A)/12) + (52.08))

= 62.50 – (114.58 + (52.08))

= 62.50 – 62.50

= $0

Reserve Lost Opportunity Cost Credit Example

- Example 2: (Secondary Reserve Only) (5-min interval)
  - DA Opportunity Cost = (40 – 25) * (350 – (285 + 50) = $225
    - DA LMP = $40
    - Energy Cost = $25 ($25 value created for example)
    - DA Energy produced = 285
    - Eco Max = 350
    - DA SR MW = 50
  - RT Opportunity Cost = $0
    - Resource was assigned less MW in RT
  - DA Clearing credit = $150 (from slide 15)
  - Market Revenue Neutrality Offset = $120.00 (from slide 30)
  - Opportunity Cost Owed = N/A
  - Bal Clearing credit = $(3.75) (from slide 18)

= ((225 + 0) / 12) – (((150 + 120.00 + N/A)/12) + (3.75))

= 18.75 – (22.50 + (3.75))

= 18.75 – 18.75

= $0

Reserve Lost Opportunity Cost Credit Example

- Example 2: (Synchronized Reserve Only) (5-min interval)
  - DA Offer = $0 * 50 = $0
    - DA Offer Price = $0 ($0 value created for example)
    - DA MW = 50
  - RT Offer = $0 * 50 = $0
    - RT Offer Price = $0 ($0 value created for example)
    - Capped RT MW = 25
  - DA Opportunity Cost = (40 – 25) * (350 – 15) – 285) = $750
    - DA LMP = $40
    - Cost = $25 ($25 value created for example)
    - DA Energy produced = 285
    - Eco Max = 350
    - DA SecR MW = 15
  - RT Opportunity Cost = $0
    - Resource was assigned less MW in RT
  - DA Clearing credit = $750 (from slide 15)
  - Market Revenue Neutrality Offset = $624.96 (from slide 30)
  - Opportunity Cost Owed = N/A
  - Bal Clearing credit = $(52.08) (from slide 18)

= ((0 + 0 + 750 + 0) / 12) – (((750 + 624.96 + N/A)/12) + (52.08))

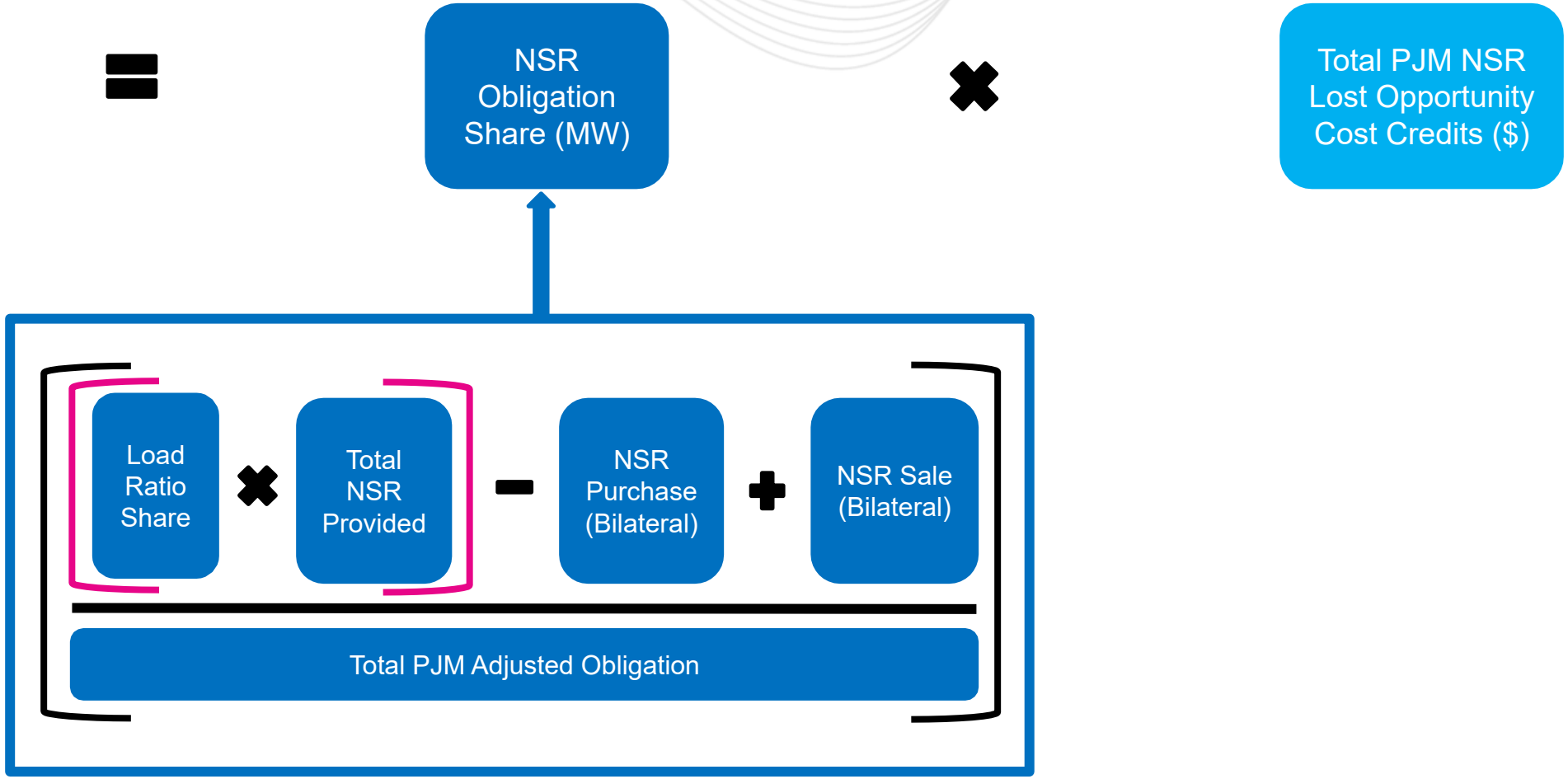
= 62.50 – (114.58 + (52.08))

= 62.50 – 62.50

= $0

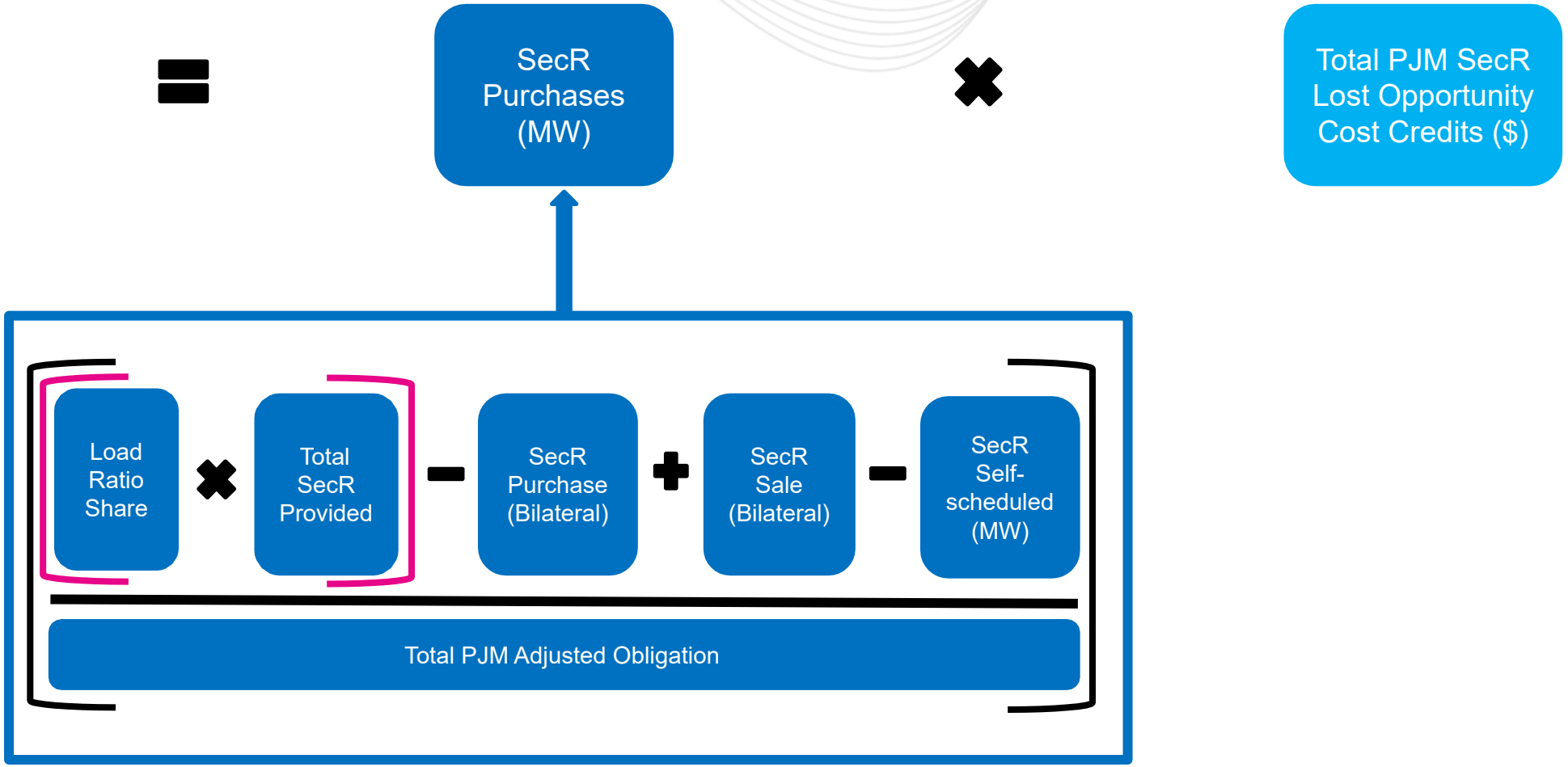
Reserve Lost Opportunity Cost Charge

- Non-Synchronized (hourly)



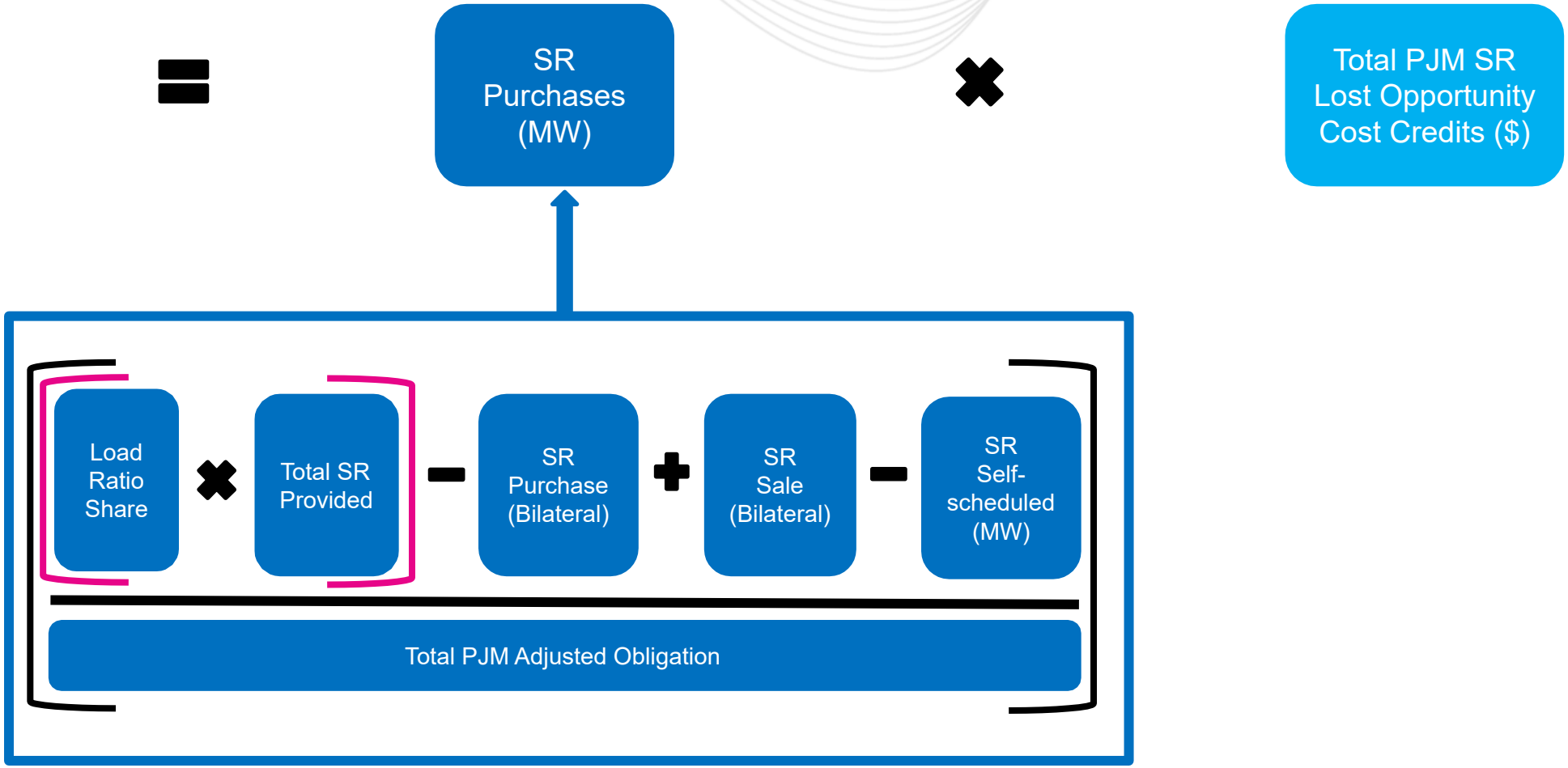
Reserve Lost Opportunity Cost Charge

- Secondary (hourly)



Reserve Lost Opportunity Cost Charge

- Synchronized (hourly)



Next Steps

- Review questions regarding calculations at the July 11, 2022 Market Settlement Subcommittee (MSS)
- Manual first reads tentatively scheduled to begin at the July standing committee meetings
  - MIC: M-11; M-15; M-18; M-27; M-28; M-29
  - SOS/OC: M-10; M-12; M-13