Fast Start Education

Market Implementation Committee

October 19, 2020

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FERC Order and Timeline

- PJM provided a tentative Fast Start Implementation plan update at the October 7, 2020 MIC

  - https://www.pjm.com/-/media/committees-groups/committees/mic/2020/20201007/20201007-item-10-fast-start-implementation-plan.ashx

- Fast Start related FERC filings:
  - August 2019 Fast Start Compliance filing held in abeyance pending Dispatch and Pricing Alignment
  - PJM filed Short-Term plan with FERC on July 31, 2020 with requested response date by October 12, 2020
    - FERC approved PJM's Short-Term filing on October 13, 2020
    - Effective date noted as October 15, 2020
    - Short Term changes successfully implemented on October 15th

- Current Implementation Timeline:
  – Education session – Monday October 19, 2020
    • Reflects Fast Start changes as filed in August 2019
  – Tech Change Forum education – Tuesday October 20, 2020
  – Fast Start Implementation scheduled for Sunday November 1, 2020
  – Implementation will be moved to Tuesday December 1, 2020 if a FERC ruling is issued after October 16, 2020
- M-11 and M-28 Updates:
  – First read in November
  – Second read/endorsement in December

- PJM is required to implement fast-start pricing
  1. Define fast-start resources as those with a total time to start and minimum run time of less than or equal to one hour
  2. Validate composite offers greater than $1000/MWh prior to setting price
  3. Implement separate dispatch and pricing runs in day-ahead and real-time markets
  4. Amortize start-up and no-load in "effective" offer using integer relaxation
  5. Use lost opportunity cost (LOC) to provide incentive to follow dispatch
  6. Address any issues regarding double payment stemming from implementation in day-ahead and real-time market

Definition and Eligibility

- Units must first be deemed Fast Start capable in order to qualify for Fast Start Pricing

- Generators based on technology type are pre-defined as Fast Start Capable by default

- Any resource not deemed as Fast Start capable may seek to be Fast Start capable during the annual review period
  - Deadline to submit request: April 15
  - PJM review period (includes consultation with IMM): April 15 – May 31
  - Effective: June 1 and onwards

- Supporting data must be provided to prove unit can startup within 1 hour

- If unit cannot meet their bid in parameters, may lose Fast Start capable designation
  - To be reconsidered, the unit may submit supporting data during the annual review period

- Resources deemed FS capable by default:
  - Generation Type:
    - Fuel Cells
    - All CTs
    - Diesels
    - Hydro
    - Battery
    - Solar
    - Landfill
    - Wind
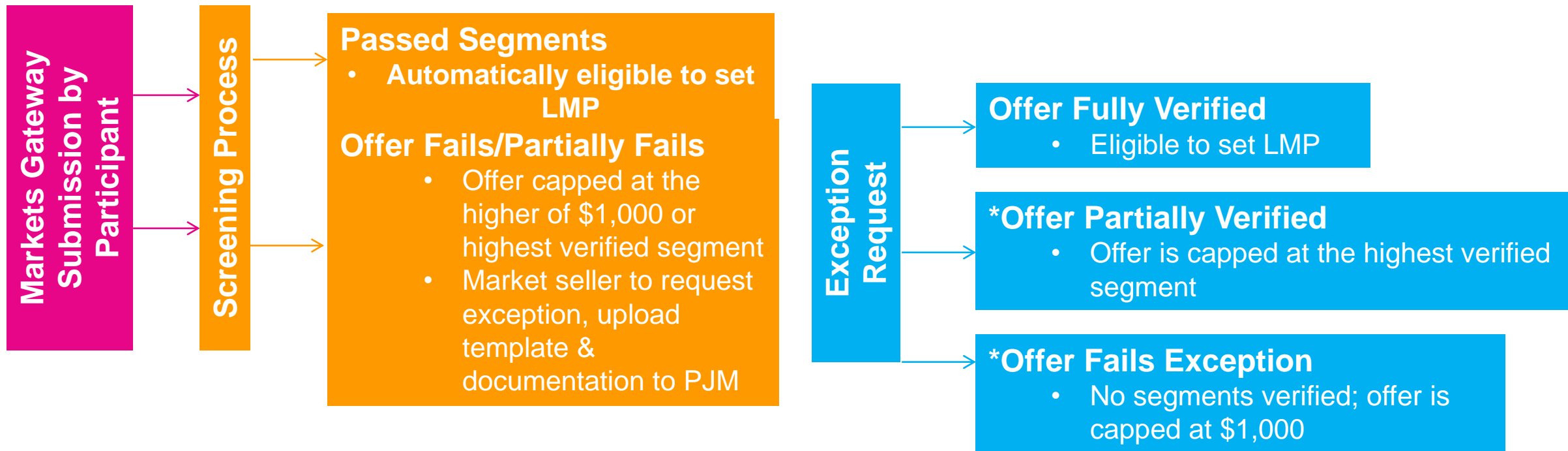 - All Economic Load Response

- Resource deemed not FS capable by default*:
  - Combined Cycle
  - Steam
  - Nuclear

*Resources may request to be considered FS Capable

- Once a unit is deemed Fast Start capable, they must also meet the following requirements in order to qualify for Fast-Start Pricing:

  - Notification Time + Startup Time <= 1 hour

  - Minimum Run Time <= 1 hour

  - Online and running for PJM

- Pumped Hydro Resources using the PJM Hydro Optimizer, partially Pseudo-tied resources, and dynamically scheduled resources are not eligible for Fast-Start Pricing

Offer Verification for Fast Start Pricing

- Order 831 requires validation of incremental energy offers above $1000 prior to using them to set LMP

Markets Gateway Submission by Participant

Screening Process

Passed Segments
- **Automatically eligible to set LMP**

Offer Fails/Partially Fails
- Offer capped at the higher of $1,000 or highest verified segment
- Market seller to request exception, upload template & documentation to PJM

Exception Request

Offer Fully Verified
- Eligible to set LMP

*Offer Partially Verified
- Offer is capped at the highest verified segment

*Offer Fails Exception
- No segments verified; offer is capped at $1,000

- FERC is mandating that a Fast Start resource's "Composite Energy Offer" over $1,000/MWh should be validated prior to being eligible to set LMP

- For Fast Start resources, "Composite Energy Offer", is incremental offers plus amortized commitment costs and will be eligible to set LMP

- For offer verification validation purposes, the Composite Energy Offer includes the amortized startup and no load cost at all times for generation resources

- For offer verification validation purposes, the Composite Energy Offer includes the amortized shutdown cost at all times for Economic Load Response resources

For Generation Resources:

- If the Composite Energy Offer is calculated to be above $1,000/MWh
  - PJM will validate the startup cost and no load cost plus incremental offer
  - If startup cost fails validation, it will be excluded from Composite Energy Offer Calculation
  - If no load cost fails validation, it will be excluded from Composite Energy Offer Calculation
  - New display in Markets Gateway to provide details
  - No changes to existing logic for validating incremental energy offers

- Each component of the price-based Composite Energy Offer must be equal to or less than the reference cost-based offer or will be capped at the validated cost-based Composite Energy Offer

- For verified Composite Energy Offers above $2,000/MWh
  - Startup Cost is first excluded from Offer
  - If Offer still exceeds $2,000/MWh, then no load cost is excluded from Offer

For Economic Load Response (ELR):

- If Composite Energy Offer is above $1,000/MWh:

  – Shutdown cost will be excluded unless the seller provided PJM supporting documentation in advance that supports the end use customer's incremental and shutdown costs exceed $1,000/MWh

  – No changes to the existing logic for validating incremental energy offers submitted to Markets Gateway

- For verified Composite Energy Offers above $2,000/MWh

  – Shutdown cost will be first excluded from offer

  – If offer still exceeds $2,000/MWh, than the incremental offer will be capped at $2,000/MWh

- For each segment on the incremental offer curve:
  - **Composite Energy Offer** = incremental offer + (no load ($) / EcoMax (MWh)) + (startup ($) / (EcoMax (MWh)*min run time))
- Reasonability Check for Startup Cost
  - **Startup Cost** = [[(Performance Factor) x (Start Fuel) x (Fuel Cost)] + Start Maintenance Adder + Additional Start Labor + Station Service Cost] x (1.1)
- Fast Start Resource Example:

Incremental Offer	Startup Cost	No Load	Composite Energy Offer	Offer above $1,000/MWh	Subject to Offer Verification?
$700	$100	$100	$900	No	No*
$700	$200	$200	$1,100	Yes	Yes

*Status quo

- Validation Details
  - Information submitted to COA and commodity cost from Platts/ICE will be used to perform validation
  - Composite Energy Offer will be calculated and validated at the resource's Economic Max MW
  - Fast Start resources with Composite Energy Offer over $1,000/MWh, will be screened and validated each time a variable affecting the Enhanced Energy Offer calculation is changed
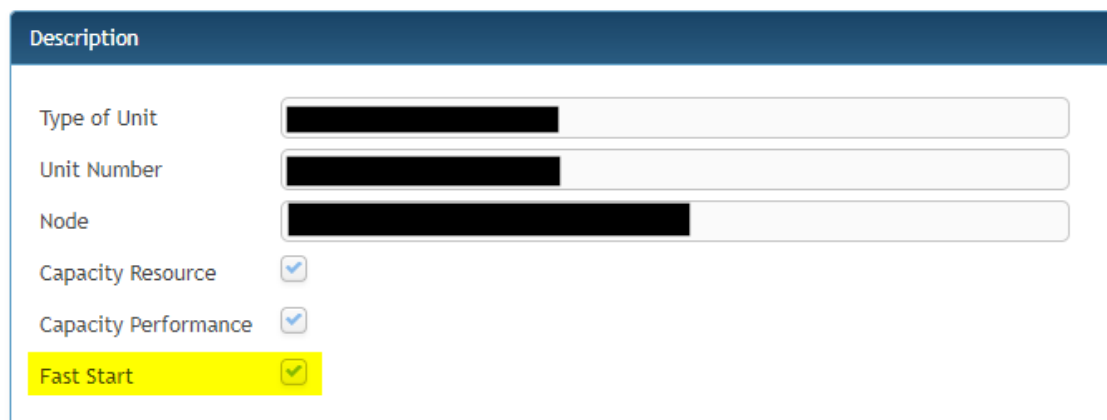
• Incremental Offer	• Minimum Run Time
• Startup Cost	• Economic Maximum MW
• No Load Cost	*Shutdown Cost for ELRs Only

- Participants will have the opportunity to submit exception request for any offers that fail validation, similar to existing exception request process

Markets Gateway Changes for Fast Start Offer Verification

- New flag denotes if the unit is capable of being a Fast Start resource

- Flag is an input to determine if the unit will be eligible for Fast Start Pricing and integer relaxation

- Only applicable for Generators on a unit level (not schedule level)

  – Generator > Unit > Details

  – All Economic Load Response resources are considered Fast Start capable

- New display added to Markets Gateway to provide information if the Composite Energy Offer is above $1,000/MWh for Fast Start Resources

- Display details
  - Read-only display
  - All inputs used to calculate the composite offer
  - Composite Energy Offer calculated at Ecomax
  - Results of automated validation of Startup Cost and No Load Cost (For Generators only)
    - Shutdown Cost for Economic Load Response
  - Results can be viewed by participant or individual unit level
  - Supports XML

Composite Energy Offer for Generators

- Composite Offer greater than > $1000/MWh with PJM approved shutdown cost of $200

- HE 13: CSP entered shutdown cost $1200 and incremental offer $26 for 1MW. Composite offer >$1000, Shutdown cost >$200 – not valid. Shutdown Cost excluded from Offer

- HE 16: CSP entered shutdown cost $300 and incremental offer $900 for 1MW. Composite offer >$1000, Shutdown cost >$200 – not valid. Shutdown Cost excluded from Offer

- HE 17: CSP entered shutdown cost $100 and incremental offer $950 for 1MW. Composite offer >$1000, Shutdown cost <$200 – valid. Offer would be $1,050

Market Day ▭ Portfolio ▭

| Offer Curve Manager | Offers | Offer Updates | Parameters | Schedule Selection | Hourly Updates | **Composite Offer Verification** |

Hour ▲	Location	Schedule	Calculated Composite Offer	Shutdown Cost Valid	Shutdown Cost	Incremental Offer At Economic Maximum	Economic Maximum	Minimum Downtime	Notificat Time
Show all ⌄		⌄	⌄	Show all ⌄	Show All ⌄	Show all ⌄	Show all ⌄	Show all ⌄	Show all ⌄	Show
13	▬	Sced2 (2)	1226	No	1200	26	1	1	
16	▬	Sced2 (2)	1200	No	300	900	1	1	
17	▬	Sced2 (2)	1050	Yes	100	950	1	1	

Dispatch and Pricing

- A separate dispatch run and pricing run will be executed in Day-ahead and Real Time Energy Markets

Dispatch Run

- Status Quo

- Make no modifications to resource parameters

- Unit Commitment

- Determines desired dispatch points sent to resources

Pricing Run

- Modify resource parameters using integer relaxation

- Calculates the final LMPs and MCPs used for Settlement

- The pricing run is calculated via a subsequent optimization using same inputs as dispatch run optimization, but performs the following:
  - Uses integer relaxation to allow Eligible Fast-Start Resources to be committed below Eco Min
    - Offline resources cannot set price
  - Includes amortized startup and no-load costs in LMP formation for Eligible Fast-Start Resources, based on results of offer verification

- Constraints included in the dispatch run solution will be included in pricing run solution:
  - Constraints may bind in dispatch run but may not bind in pricing run and vice versa

- Shortage pricing will only be triggered based upon the pricing run:
  - There are typically less reserves available in the pricing run than in the dispatch run, so false negative shortages (short in dispatch run but not in pricing run) are unlikely

- Startup cost and No Load Cost are amortized and included in LMP formation:
  - Startup cost is amortized across the resources min run time
  - No Load cost is amortized for the duration the unit is online and running for PJM

- A unit can specify a Minimum Run Time less than one hour:
  - Day-Ahead will amortize startup costs over the entire hour as that is the smallest duration of a commitment
  - Real-time will amortize start-up cost over its actual Minimum Run Time as that is the smallest duration of a commitment in RT:
    - Start-up cost will be amortized over first 5 minute interval if Minimum Run Time of the unit is 0
    - Start-up cost will be amortized over the whole 5 minute interval if Minimum Run Time of the unit falls between two target intervals. For example, if Unit's Minimum Run Time is 27 minutes, then Start-up cost will be amortized over six 5 minute intervals

Fast Start Pricing –
Market Settlement Changes

- Dispatch Differential Lost Opportunity Cost Credits
- Day-ahead Scheduling Reserve (DASR) Lost Opportunity Cost Credits
- Day-ahead Transaction Make Whole Payments
- Real-Time Make Whole Credit
- Double Counting of Commitment Costs

- The FERC order accepted PJM's proposal to use lost opportunity cost (LOC) credits to offset the incentive for over-generation or price chasing
  - Incentive can exist when a resource is dispatched down to maintain power balance due to the need to accommodate the inflexibility of fast-start resources as well as the inclusion of commitment costs into the LMP
  - Pool-scheduled and dispatchable self-scheduled resources are eligible to receive this LOC credit

- **Objective**
  - Minimize incentive for a resource to deviate from dispatch instructions by chasing LMP

- **Approach**
  - Calculate a Dispatch Differential LOC (DD LOC) that is the difference between additional revenue above cost that a resource would have received if it operated at the Pricing Run MW and the actual revenue above cost the resource earned

- Resources will continue to receive eligible LOC credits if scheduled for:
  – Regulation
  – Synchronized Reserve
  – Reactive Services
  – Reduced or suspended due to a transmission constraint or for other reliability reasons
- For these resources, existing LOC credits cover the differences between the pricing run and the dispatch run and as a result these resources will not be eligible for DD LOC
- Eliminates the potential for duplicate LOC credits for the same MWs

- Dispatch Differential LOC will only be calculated for the Real-time Market

- Dispatch deviations can only occur in the real-time energy market, so this LOC does not apply to the Day-ahead market

- Five-minute interval based calculation

- Dispatch Differential LOC will equal the positive difference between the revenue above cost that a resource would have received if it operated at the Pricing Run MW and the actual revenue above cost the resource earned

- Dispatch Differential LOC credits will be allocated to real-time load plus exports on an hourly basis

- Pricing Run Revenue Above Cost

  (Expected MW Output * LMP_P) – Incremental Energy Offer for Expected MW Output

    Expected MW Output is the MW value of the resource based on the Final Offer at the five minute real-time LMP at the resource bus

- Dispatch Run Revenue Above Cost

  Greater of (Dispatch MW, Actual MW) * LMP_P –

  Lesser of (Cost of Dispatch MW, Cost of Actual MW)

- Dispatch Differential LOC Credit = Max(Pricing Run Revenue Above Cost – Dispatch Run Revenue Above Cost, 0)

Dispatch Differential LOC Calculation

Segment	MW	Price	Cost
1	85	$20	$1700
2	95	$27	$235
3	100	$30	$142.50
Total Cost			$2077.50

	Dispatch Run	Pricing Run
Energy	85 MW	100 MW

	Value
Dispatch MW	85 MW
Actual MW	85 MW

Pricing Run Revenue Above Cost = (Expected MW Output * LMP_P) – Incremental Energy Offer for Expected MW Output

$\qquad$ = (100 MW * $30/MW) - $2077.50

$\qquad$ = $3000 – $2077.50

$\qquad$ = $922.50

Dispatch Run Revenue Above Cost = Max (Dispatch MW, Actual MW * LMP_P) – Min (Cost of Dispatch MW, Cost of Actual MW)

$\qquad$ = (85 MW * $30/MW) – (85 MW * $20/MW)

$\qquad$ = $2550 - $1700

$\qquad$ = $850

Dispatch Differential LOC Credit = Pricing Run Revenue Above Cost - Dispatch Run Revenue Above Cost

$\qquad$ = $922.50 - $850

$\qquad$ = $72.50

Dispatch Differential LOC Calculation

Dispatch Differential
LOC Credit

LMP_P

$30/MWh

$27/MWh

$20/MWh

85 MW   95 MW   100 MW

Pricing Run Revenue Above Cost
$922.50

Dispatch Run Revenue Above Cost
$850

Dispatch Differential LOC Credit
$72.50
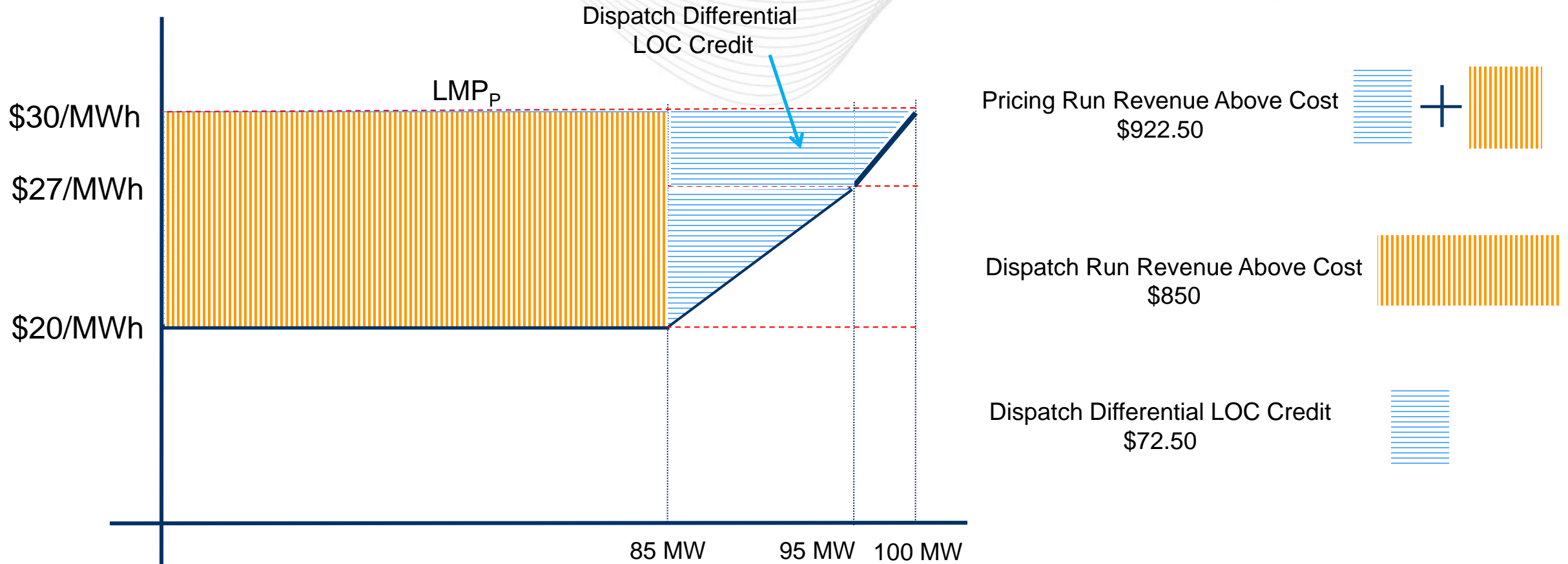
- With Fast Start Pricing, LOC is calculated to ensure that the DASR MW the resource is backed down in the Day-ahead dispatch run receives the same revenue above cost the resource could have received if it had been assigned energy for that same quantity
  - Goal is to maintain indifference between providing energy and reserves
- If DASR Clearing Price Credits < (Offer + Lost Opportunity Cost), resource is eligible for DASR LOC credit
- Introduces new Billing Line Item for DASR LOC credit

Day-ahead Scheduling Reserve (DASR) LOC

Dispatch Run	
Energy MW	DASR MW
85 MW	15 MW assignment (backed down 10 MW)
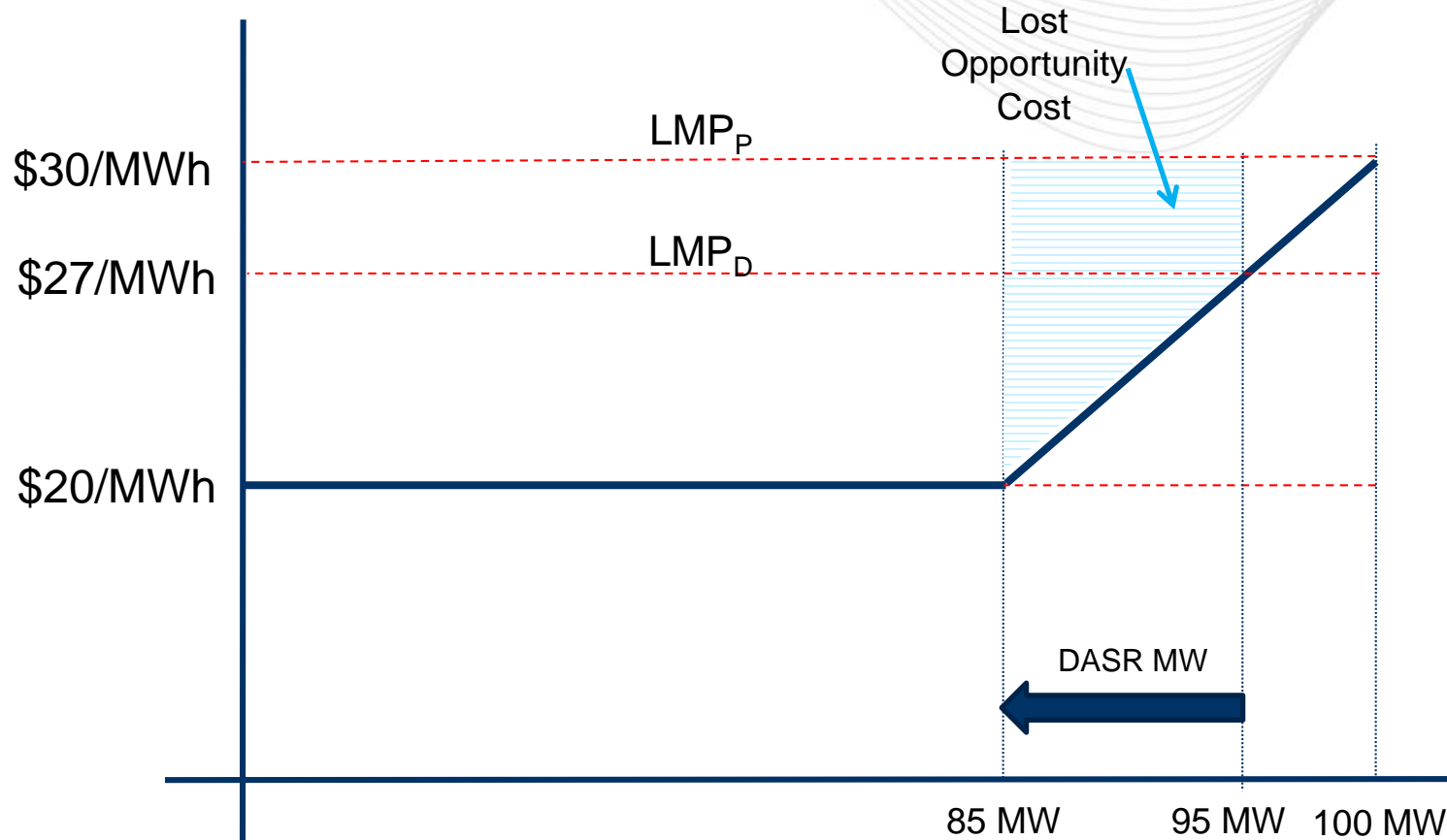
Lost Opportunity Cost = $65
This value is the foregone revenue, not the Lost Opportunity Cost Credit.

The LOC Credit is based on the difference between the DASR credits and (Offer + LOC)

LOC not paid for MW from 95 to 100 MW. This is the equivalent of DD LOC, which is not being paid in the Day-ahead market.

- Day-ahead Transactions include:
  - Virtual Transactions   - Price Responsive Demand
    - Increment Offers   - Dispatchable Exports
    - Decrement Bids
    - Up-to Congestion Transactions

- Transactions that clear in the Day-ahead dispatch run but are not economic in the Day-ahead pricing run will be made whole to their offer

- These credits represent the cost of MWs that are provided in real-time in excess of the resource's day-ahead assignment that are not compensated by real-time LMP

- Credits only apply to pool-scheduled or dispatchable self-scheduled resources

- Eligibility rules:

  1. Real-time dispatch MW greater than day ahead assignment

  2. Real-time dispatch MW greater than the output level of the resource based on the intersection of RT LMP with the offer curve

A. Using Final Offer, calculate the cost of the MWs between the:

   (1) Greater of DA Schedule MW and expected MW output at RT LMP

   AND

   (2) Lesser of RT Dispatch MW and actual MW output

B. Calculate the revenue for the MW difference between (1) and (2) at RT LMP

C. The Real-Time Make Whole Credit is equal to the positive difference between the cost and revenue: A – B.

Real-Time Make
Whole Credit
$7.50

LMP$_P$

$30/MWh

$27/MWh

$20/MWh

90 MW   95 MW   100 MW
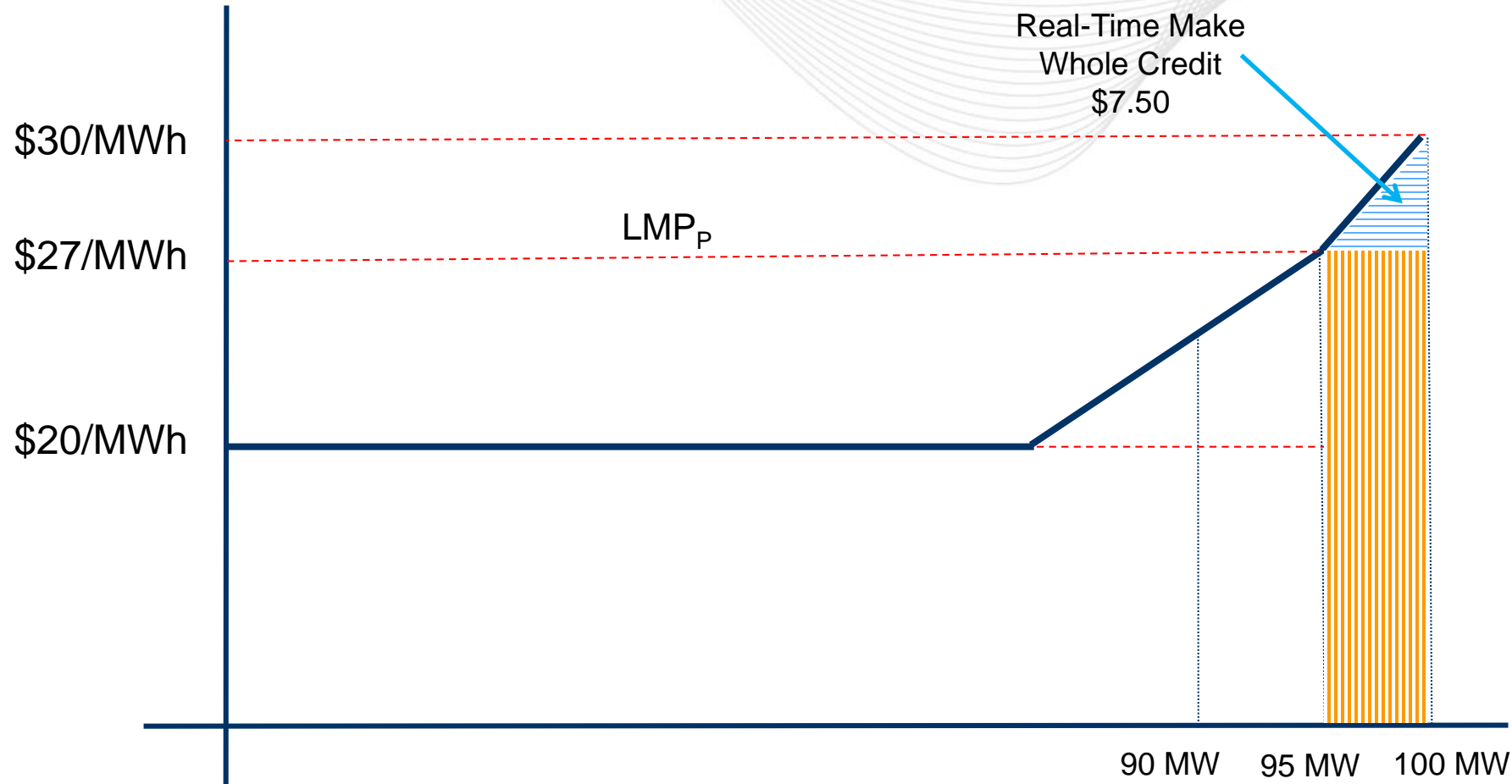
DA Schedule = 90 MW

Expected MW at RT LMP = 95 MW

RT Dispatch = 100 MW

Actual Output = 100 MW

Cost of MWs
$142.50

Revenue for
MW difference
$135
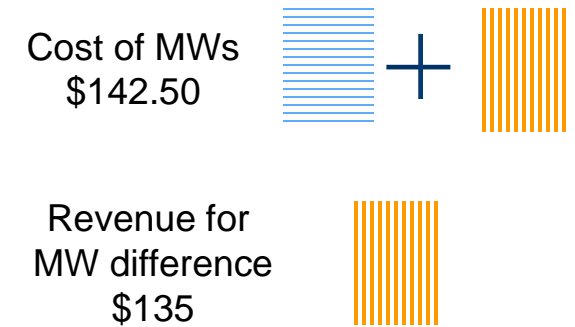
- Status Quo
  - Balancing Operating Reserve segments

- Changes
  - Real-Time Make Whole Credit is an additional revenue component to offset Balancing Operating Reserve credits

A resource is dispatched higher in real-time than in day-ahead

(positive balancing MW)

AND

The resource is made-whole for 100% of its startup and

no-load costs in day-ahead.

When these are true, the resource has an opportunity to collect revenues in real-time to cover costs that have already been compensated via day-ahead uplift.

This situation can occur today and is not unique to Fast-Start Pricing.

- Costs recovered via uplift in the Day-Ahead Market that are subsequently recovered in Real-time Market revenues are subtracted from Day-ahead uplift

- Implemented by calculating Operating Reserve Targets:

  – Day-Ahead Operating Reserve Target = Total DA Offer Cost* – DA Revenue

  – Balancing Operating Reserve Target = Total RT Offer Cost* – Total Revenue**

*Total Offer Cost includes Incremental Offer + Startup + No Load

**Total Revenue includes DA Credits + Balancing Credits + Ancillary Service Revenue + Real-time Make Whole Credits

- The total Operating Reserve Credits are capped to ensure no over payment
  - DA OR Credit Offset = MAX(DA OR Target - Bal OR Target, 0)
  - Bal OR Credit = MAX(Bal OR Target – DA OR Credit, 0)
    - The balancing credit is equal to the portion of balancing uplift that wasn't recovered via Day-Ahead uplift (Status quo)
- This calculation will apply to all resources, not only Fast-Start

DA OR Target	Bal OR Target	Day-ahead OR Credit Offset	Day-Ahead OR Credit	Bal OR Credit	
$90	$100	$0	$90	$10	Status Quo
$100	$100	$0	$100	$0	Status Quo
$110	$100	$10	$100	$0	Over Payment Resolved
$50	$0	$50	$0	$0	Over Payment Resolved