

# NYISO/PJM

## Market-to-Market Coordination

Joint Stakeholders Meeting

July 21, 2011 / Rensselaer, NY



# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement Discussion
- Post-Processing Validation
- Next Steps



# Joint Operating Agreement

---

- What is a Joint Operating Agreement (JOA)?
  - Provides for interregional coordination of TOP, BA, RC, and other NERC functions for interconnection systems and for reliable operations of the interconnections and efficient markets
- PJM and NYISO are adding a market-to-market (M2M) coordination process to their existing JOA
  - M2M coordination is a mechanism that permits market entities to control parallel flows in an economic manner that consistently ensures system reliability and efficient markets

# Background

---

- On January 12, 2010, the NYISO filed a report with FERC describing the Broader Regional Markets suite of solutions, including M2M coordination, to address loop flows
- On July 1, 2011, FERC approved the schedule for implementing M2M
  - JOA Filing 4<sup>th</sup> Quarter 2011
  - M2M Implementation 4<sup>th</sup> Quarter 2012
- NYISO and PJM are required to implement M2M by the end of 2012.
  - See 133 FERC 61,276 at P. 32, *on reh'g* 136 FERC 61,011 at P. 16.
- Throughout 2011, the NYISO and PJM have been collaborating on M2M implementation

# Market-to-Market Coordination

---

- ✓ Achieves **least cost re-dispatch** solution
- ✓ Provides **consistent pricing** profile across two markets
- ✓ Enhances **system reliability**
- ✓ Potomac Economics estimates production cost benefits of M2M as follows:
  - ✓ NYISO with PJM approximately **\$10M annually**
  - ✓ PJM with NYISO approximately **\$5M annually**
- ✓ PJM Benefits with MISO for April 2005
  - ✓ PJM to MISO settlement \$367k
  - ✓ PJM estimated market costs to re-dispatch \$4.3M

# M2M JOA Provisions

---

The M2M amendments to the JOA addresses the following topics:

- Exchange of data and information
- Identifying M2M flowgates
- Determining M2M entitlements
- Calculating real-time M2M market flows
- Setting scope of appropriate use of M2M coordination
- Calculating M2M settlements
- Lessons learned from MISO-PJM JOA

# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation
- Next Steps



# Project Timeline

<u>Task</u>	<u>Delivery by End of</u>
Market Flow Calculator o Includes specification, development, testing, and implementation of calculation engine, incorporating common treatment for PAR operational requirements and model representation	3rd QTR – 2011
Joint Operating Agreement o Includes defining entitlements and filing for Commission approval	4th QTR – 2011
Software Specifications o Completion of documentation defining changes necessary to administer real-time constraint coordination, settlement administration, audit and validation	3rd QTR – 2011
Software Development o Completion of software tools necessary to administer and settle Market-to-Market outcomes, and validate the results	2nd QTR – 2012
Software Ready o Completion of software validation, including finalized software development, software performance and completeness testing, process validation and operator training	4th QTR – 2012
o Implementation	4th QTR – 2012





# Progress Report

---

- Status of JOA filing
- Status of development efforts
- Draft of JOA M2M August 2011



# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation
- Next Steps



# Key Concepts

---

## Real Time / Market-to-Market Coordination

- A mechanism for NYISO and PJM to provide more cost effective management of constraints from a larger pool of resources

## Monitoring RTO (MRTO)

- The RTO that has the primary responsibility for monitoring and control of a coordinated Flowgate

## Non-Monitoring RTO (NMRTO)

- The RTO that does not have the primary responsibility for monitoring and control of a Flowgate, but does have resources that impact the Flowgate

# Key Concepts

---

## Market Flow

- The flow in MW on a Flowgate that is caused by all real-time control actions to serve load in the RTO footprint

## M2M Flowgate

- A Flowgate that may be significantly impacted by the dispatch of generation serving load in an adjacent market

## Entitlements

- Predetermined MW amount that a market entity is entitled to per Flowgate based on its historical impacts to that Flowgate. In the M2M process, real time usage is compared to entitlement to determine settlement

# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation



# Purpose

---

## Reduces Congestion

- Expands the pool of assets that are capable of addressing the region's transmission constraints
- Provides better price convergence at the borders as a collective set of assets are used to resolve system limitations

## Reduces the Overall Cost Of Congestion

- Provides an RTO with the ability to request generation re-dispatch from neighboring market
- Solves internal constraints at a lower cost

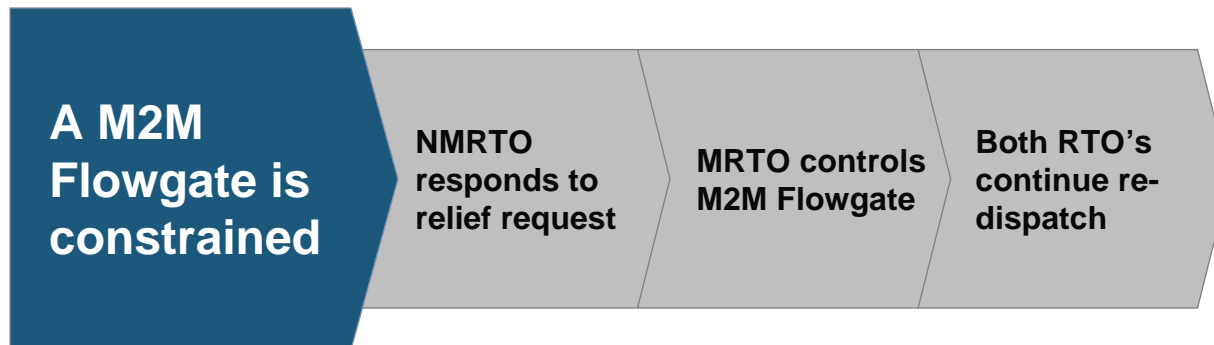
# Initiation & Operation

---

- M2M coordination is manually invoked by NYISO and PJM operations when an M2M Flowgate is constrained
- Manual coordination of NYISO and PJM Operations:
  - M2M Initiation/Activation notifications
  - Additional Transmission Outage notifications
- Automated data exchange to manage M2M re-dispatch:
  - M2M Flowgate Identification
  - M2M Flowgate Shadow Cost
  - M2M Flowgate Relief Request MW

# Process

---



- MRTO controls the constraint
- A request is sent to the NMRTO to enter into M2M coordination
- The request includes:
  - M2M Flowgate ID
  - Shadow Cost
  - Relief Request MW



# Process

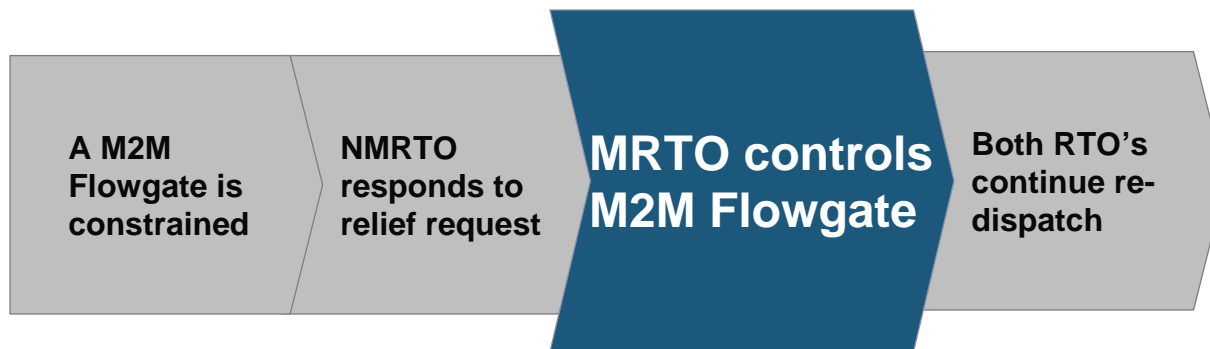
---



- NMRTO Responds to the relief request from the MRTO by:
  - Providing the MW relief requested by the MRTO to control the M2M Flowgate; or
  - Re-dispatching up to the current shadow price from the MRTO

# Process

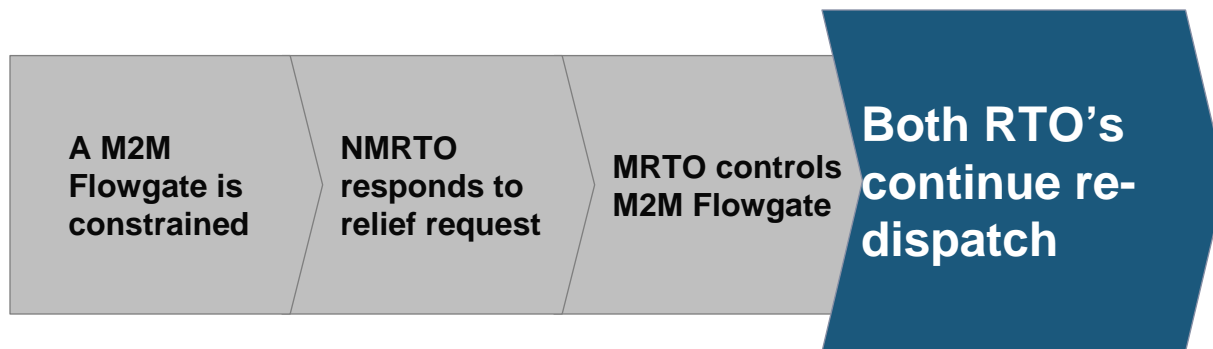
---



- The relief provided by the NMRT0 is realized on the M2M Flowgate
- The MRTO should be able to control the flowgate at a lower shadow price
- The updated shadow price and relief request MW is sent to the NMRT0

# Process

---



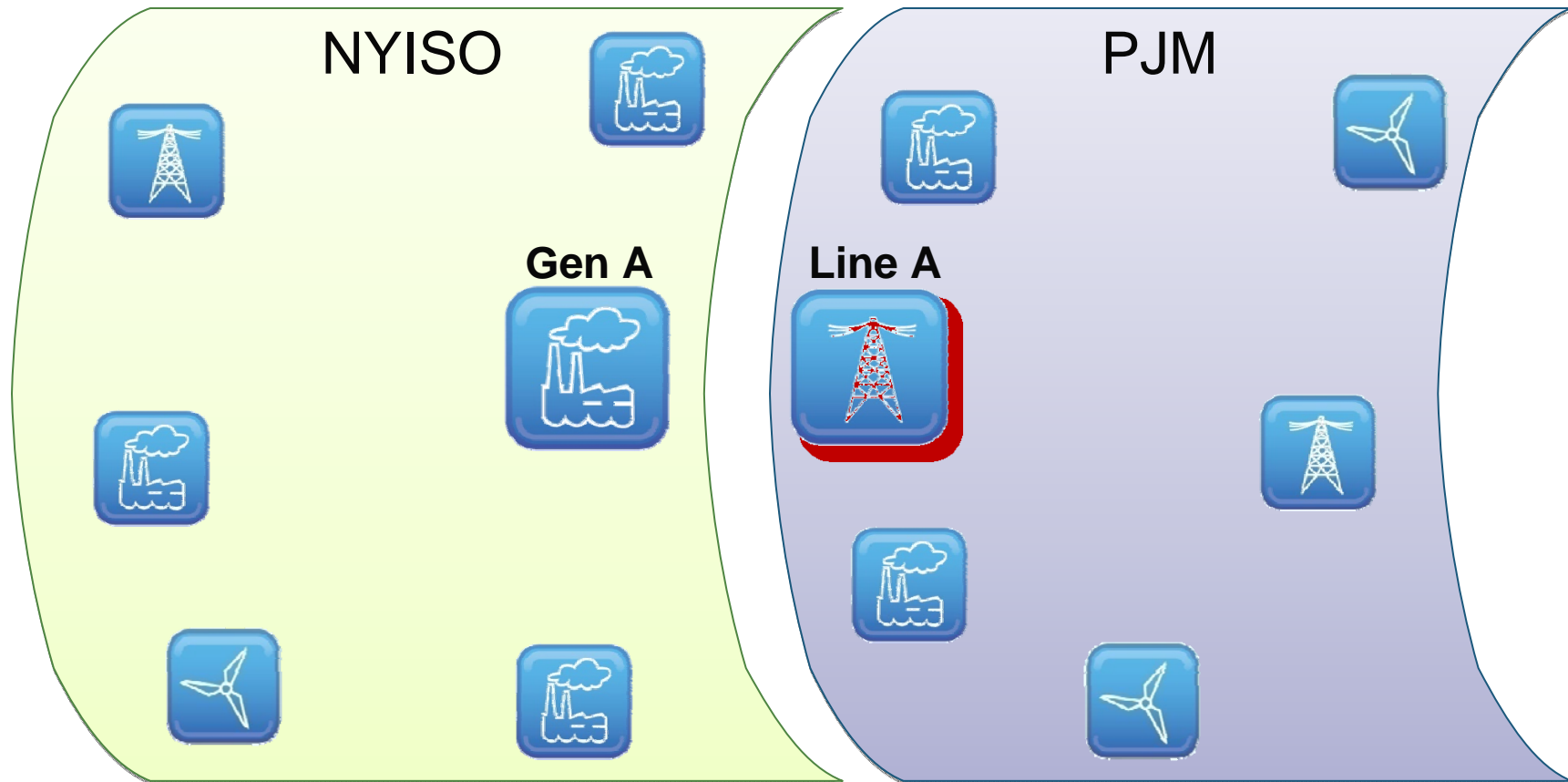
- Both RTOs continue to re-dispatch their systems, respecting the constrained M2M Flowgate, until it is no longer constrained

# Outcome

---

- A cost effective re-dispatch solution for the combined footprint
- RTOs compensate each other for the re-dispatch provided based on the real time market flow of the NMRTO compared to the Entitlement

# Management of Constraint



- Congestion on Line A causes PJM to initiate M2M
- NYISO enters Line A into security-constrained dispatch
- NYISO lowers Gen A and congestion is reduced on Line A

# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation
- Next Steps



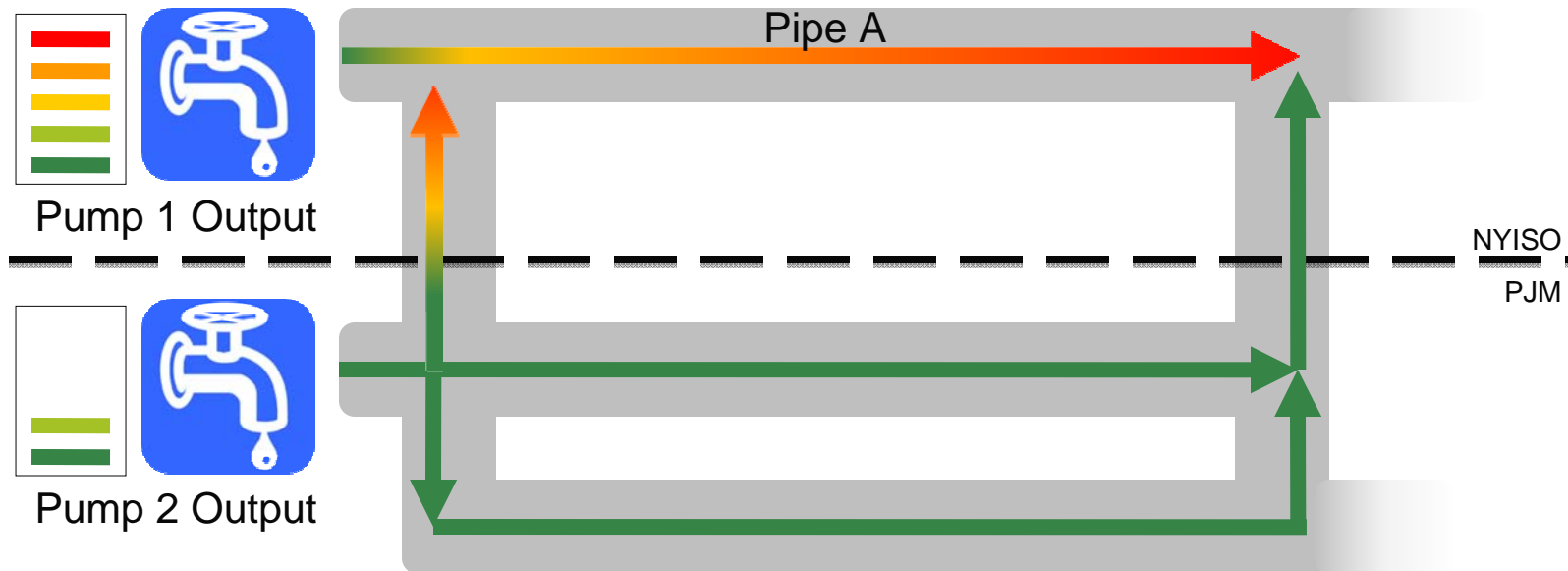
# Market-to-Market (M2M)

---

- A mechanism for NYISO and PJM to provide more cost effective management of constraints from a larger pool of resources
- Provides for settlement between markets when assistance is provided
- Compensation is based on entitled use of the system

# M2M Coordination

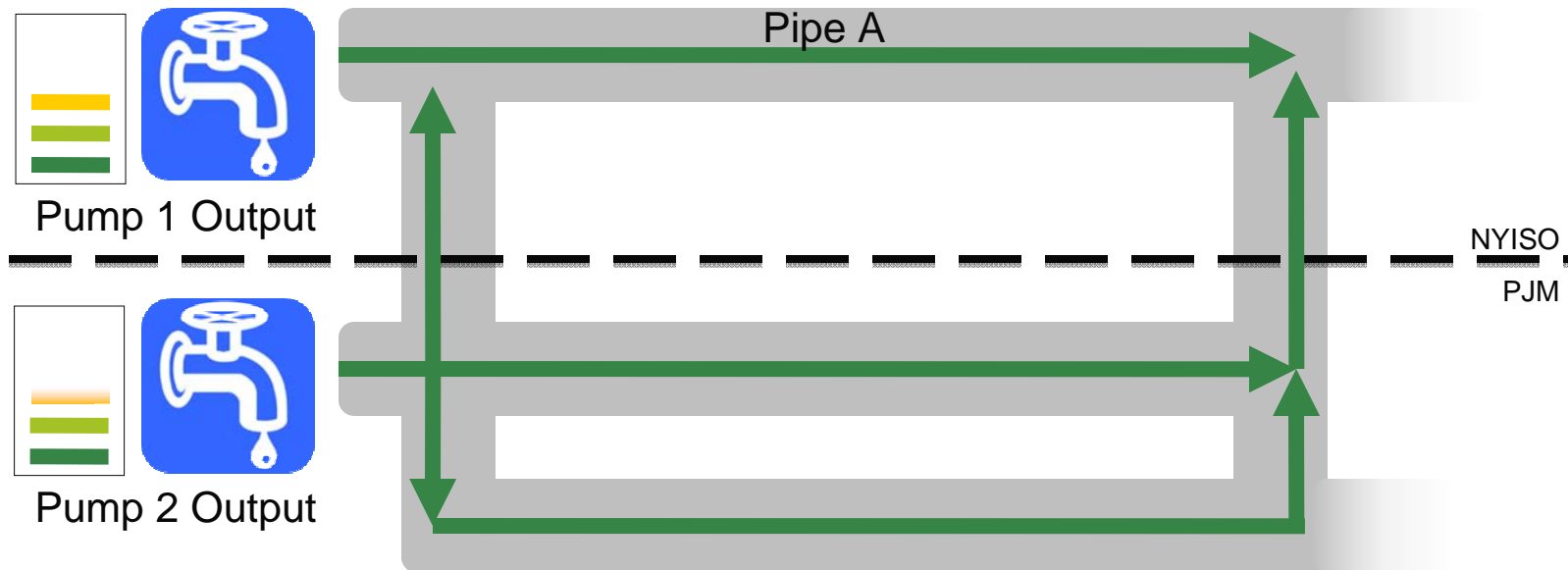
- NYISO constraint on pipe A
- NYISO's pump 1 high output
- PJM's pump 2 low output





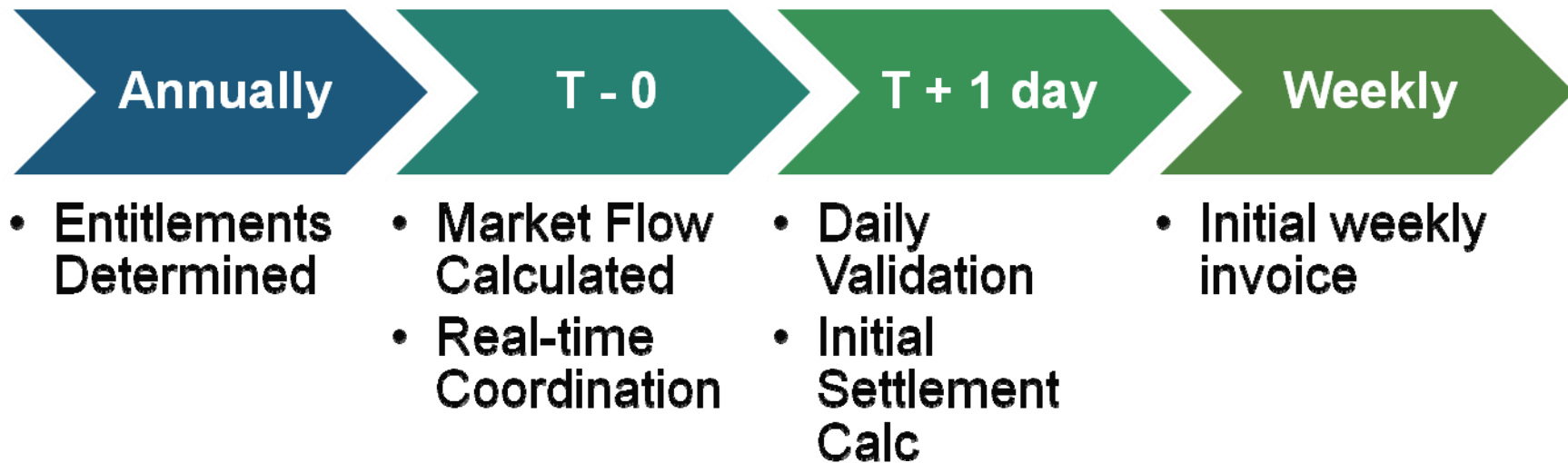
# M2M Coordination

- NYISO reduces pump 1
- PJM increases pump 2 to assist NYISO
- Pipe A flow reduces by joint control



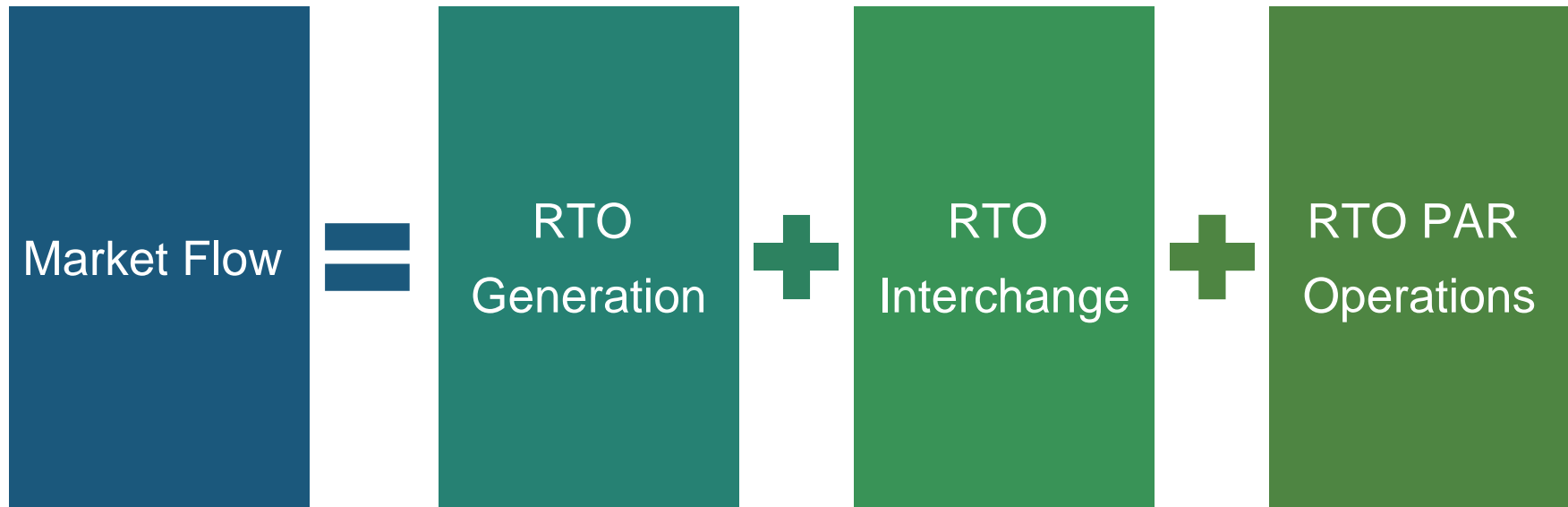
# M2M Coordination Timeline

---

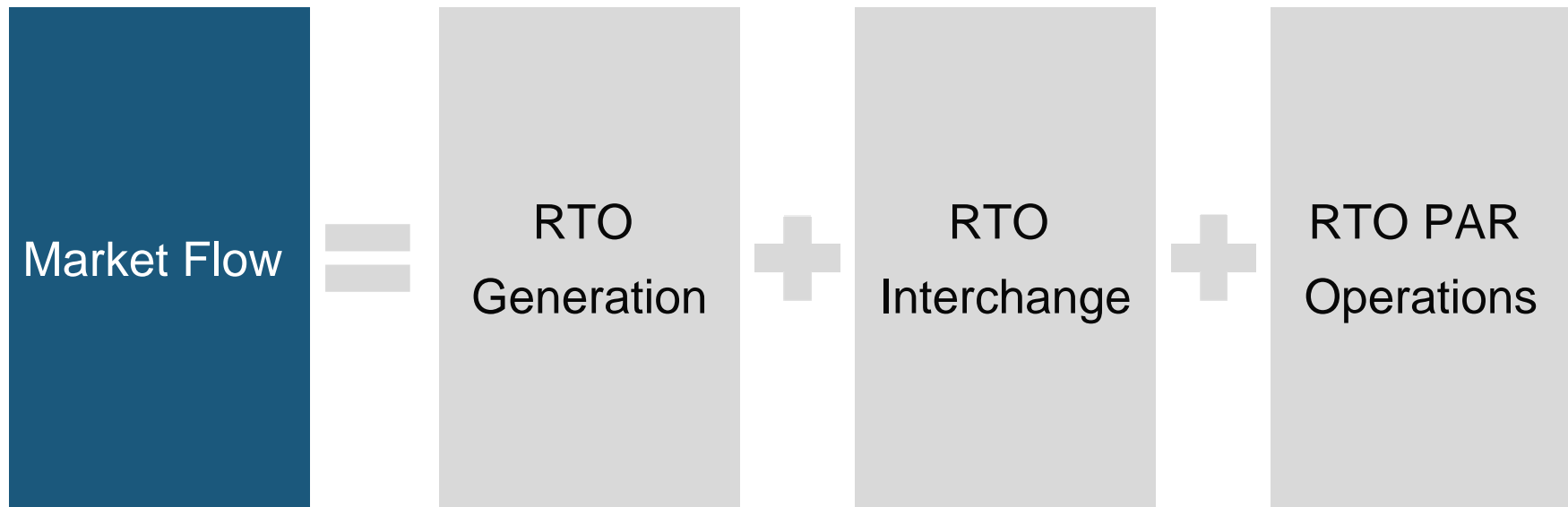


# Market Flow Calculation

---

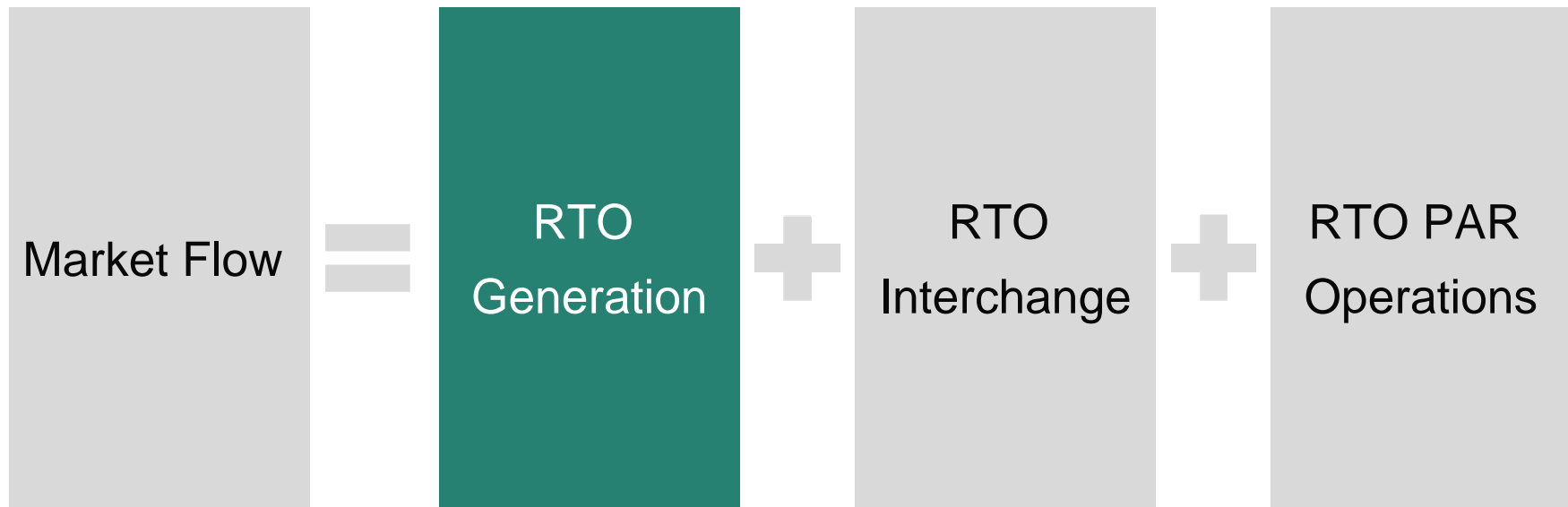


# Market Flow Calculation



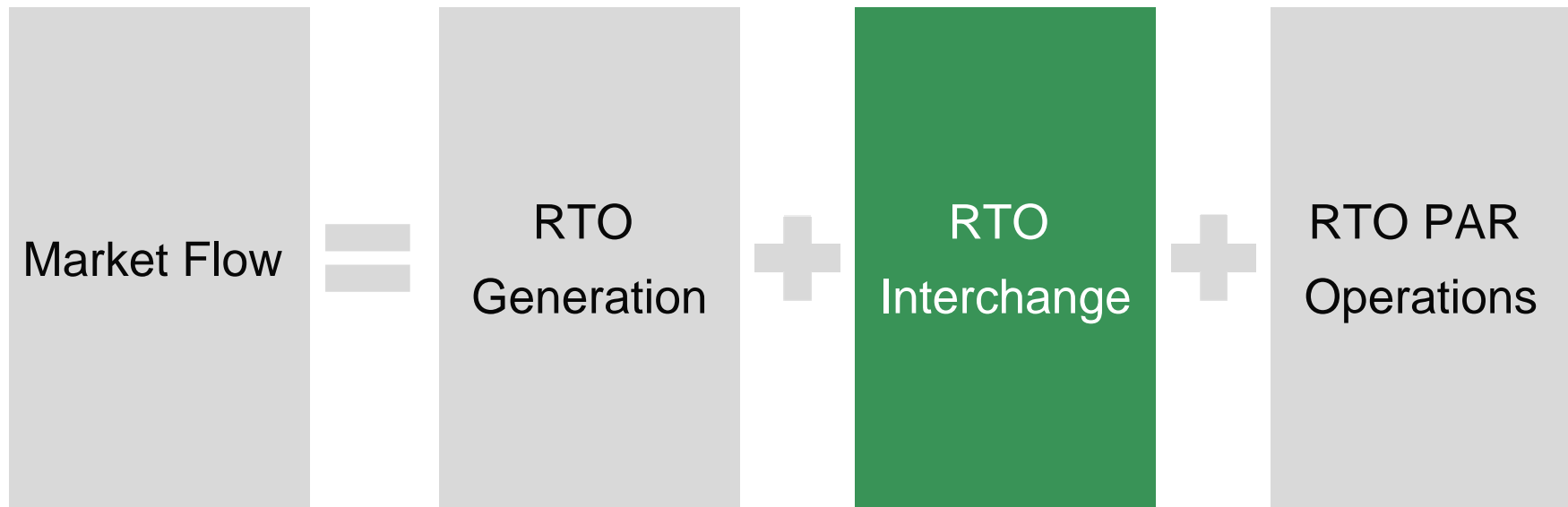
- The measure of flow on a transmission facility that is caused by RTO market operations
- Based on a common set of equations
- NYISO and PJM will compute their own Market Flows

# Market Flow Calculation



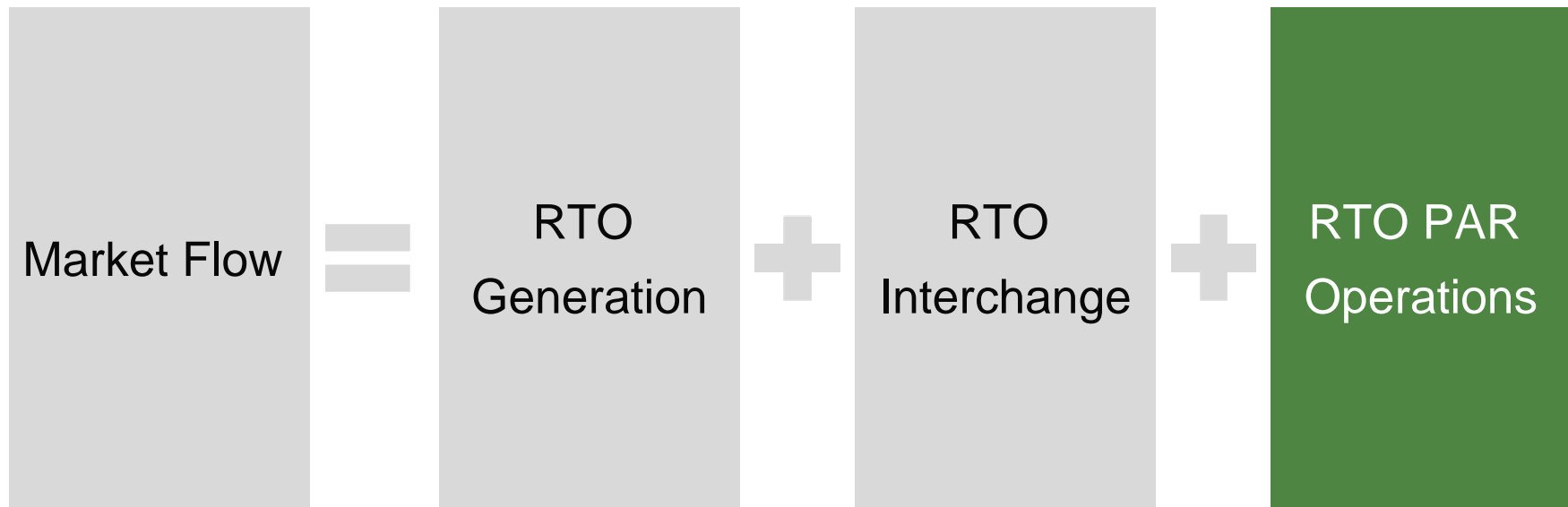
- RTO Generation impacts are determined by computing generation-to-load distribution factor on the M2M Flowgate

# Market Flow Calculation



- RTO Interchange impacts are determined by computing the transfer distribution factor on the M2M Flowgate

# Market Flow Calculation



- PAR Operation impacts are determined by computing the PAR distribution factor on the M2M Flowgate

# M2M Example

- Assume a NYISO transmission line is constrained:
  - Flowgate rating = 400
  - Flow on flowgate approaches 400 MW limit

Market	Status	Shadow Price (SP)	Initial Market Flow	Action
NYISO	Monitoring RTO	\$300	150 MW	Bind
PJM	Non-Monitoring RTO	\$250	200 MW	Bind based on SP

- It is more economic for PJM to control the constraint because of the lower shadow price of \$250/MW
- Non-Monitoring RTO (PJM) redispatches when its shadow price warrants



# M2M Flowgates

---

- A Flowgate that may be significantly impacted by the dispatch of generation serving load in an adjacent market
- A Monitoring RTO Flowgate will be considered a M2M Flowgate if the Non-Monitoring RTO generation impacts the Monitoring RTO Flowgate

# M2M Flowgates

---

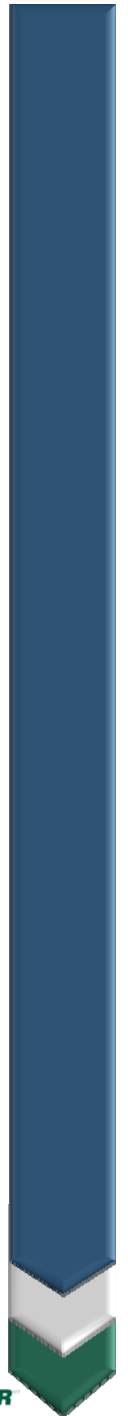
- NY Flowgates – Initial Set
  - Dysinger East Interface
  - West Central Interface
  - Central East Interface
  - Leeds - Pleasant Valley Line for the loss of:
    - Athens – Pleasant Valley Line
    - Leeds – Hurley Avenue Line
    - Athens – Pleasant Valley & Leeds – Hurley Avenue Lines
  - Additional Flowgates may be added in later phases



# M2M Flowgates

---

- PJM Flowgates – Initial Set
  - PJM East Interface
  - Erie West TX1 for the loss of Erie West-Erie South Line
  - Erie West TX3 for the loss of Erie West-Erie South Line
  - Keystone-Juniata & Conemaugh-Juniata Parallel Lines for the loss of:
    - BlackOak-Bedington Line
    - Conemaugh-Keystone Line
    - Pruntytown-Mt. Storm Line
  - Additional Flowgates may be added in later phases



# Entitlements

---

- Predetermined MW amount that a market entity is entitled to based on its historical impacts to a Flowgate
- Calculated based on prior usage of neighboring system:
  - Historic transmission representation with “No Outages”
  - Recognition of additional transmission investment (new facilities) by the market participants in a particular market
  - Consistent with the real-time Market Flow calculation

# Consistent MF & Entitlement

	Market Flow	Entitlement
Model / Topology	Real-Time	“No outage” model
Topology	Real-Time	“No outage” model
Generation	Real-Time	Historic
Load	Real-Time	Historic
Interchange	Scheduled	Zero
PAR Redirect	Schedule - Actual	Zero



# M2M Summary

---

- Entitlement with historic based topology
- Consistent Market Flow and Entitlement
  - Generation + Interchange + PAR Operations
- Ongoing validation; limited dispute

# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation
- Next Steps



# Market Settlements

- Compare RT market flow contribution from Non-Monitoring RTO dispatch to flow entitlement

## Flow > Entitlement

Non-Monitoring RTO is overusing the Monitoring RTO's transmission system

Non-Monitoring RTO payment to Monitoring RTO

Payment =  
(Market Flow - Entitlement) \*  
Shadow Price in Monitoring RTO

## Flow < Entitlement

Non-Monitoring RTO is underutilizing its entitlement on the Monitoring RTO's transmission system

Monitoring RTO payment to Non-Monitoring RTO

Payment =  
(Market Flow - Entitlement) \*  
Shadow Price in Non-Monitoring RTO



# M2M Example (cont'd)

- Assume PJM provides 20 MW of relief (decreasing market flow)
  - Flowgate rating = 400

Market	Status	Shadow Price	Initial Market Flow	New Market Flow	Entitlement
NYISO	Monitoring RTO	\$300	150 MW	150 MW	200 MW
PJM	Non-Monitoring RTO	\$250	200 MW	180 MW	200 MW

- PJM Market Flow < Entitlement
  - Monitoring RTO payment to Non-Monitoring RTO
  - Settlement from NYISO to PJM
  - Payment = (New Market Flow - Entitlement) \* Shadow Price<sub>PJM</sub>
  - = (180 – 200) \* \$250 = -\$5,000

# M2M Example 2

- Assume PJM provides 20 MW of relief (decreasing market flow)
  - Flowgate rating = 400

Market	Status	Shadow Price	Initial Market Flow	New Market Flow	Entitlement
NYISO	Monitoring RTO	\$300	150 MW	150 MW	240MW
PJM	Non-Monitoring RTO	\$250	200 MW	180 MW	160 MW

- PJM Market Flow > Entitlement
  - Non-Monitoring RTO payment to Monitoring RTO
  - Settlement from PJM to NYISO
  - Payment = (New Market Flow - Entitlement) \* Shadow Price<sub>NYISO</sub>
  - = (180 – 160) \* \$300 = +\$6,000

# M2M Settlement

---

- Since the M2M Real-Time Coordination Process is reducing congestion, NYISO will allocate the M2M hourly credit or charge to the loads through Real-Time Congestion Residuals
- M2M Coordination Settlements will be invoiced weekly by the NYISO

# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation
- Next Steps



# Post-Processing Validation

---

- Processes to identify and respond to any unexpected market outcomes that are a result of a M2M coordination
- Market Flow Calculation Verification
  - The MRTO is responsible for re-calculating the NMRTO's Market Flows on the MRTO flowgates
  - Market Flow Calculator used for validation will be the same as the Real Time Market Flow Calculator
- Settlement Data Validation
  - Verify Market-to-Market components used for invoicing
- Trending Analysis
  - Understand performance and market impacts of Market-to-Market

# Agenda

---

- Joint Operating Agreement (JOA) Overview
- Project Timeline & Progress Report
- Key Concepts
- Real-Time Coordination
- Market Flow & Entitlement
- Settlement
- Post-Processing Validation
- Next Steps



# Next Steps

---

- JOA Draft for Stakeholder Review in August
- Incremental feedback should be provided via individual stakeholder process
- Additional joint stakeholder meeting in October as needed

# Appendix

July 21, 2011 / Rensselaer, NY





# Acronyms

---

- CF - Coordinated Flow Gate
- FFE – Firm Flow Entitlement
- JOA – Joint Operating Agreement
- MRTTO – Monitoring RTO
- M2M – Market-to-Market
- MF – Market Flow
- NMRTTO – Non-Monitoring RTO
- NNL – Network Native Load
- SP – Shadow Price

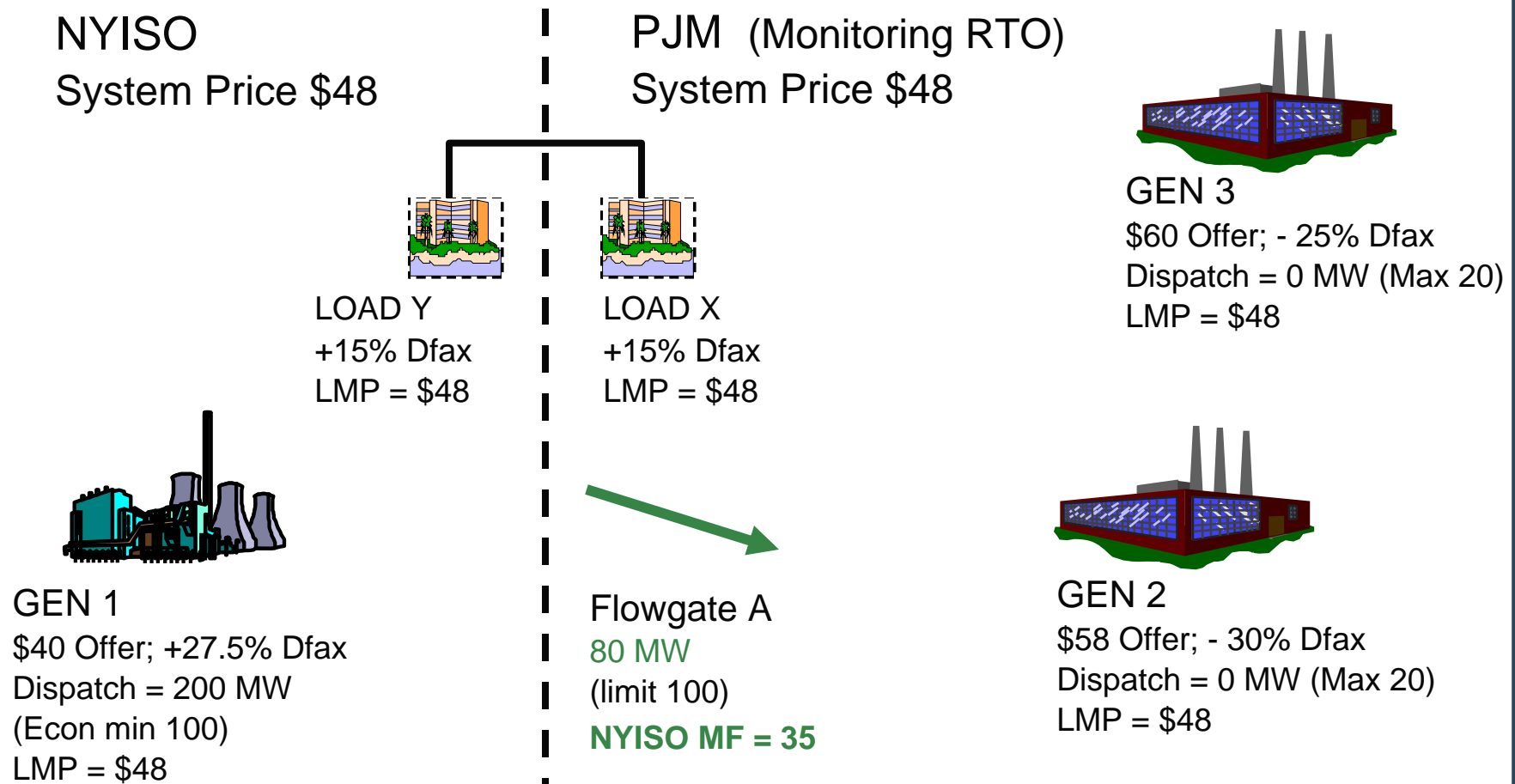


---

# REAL-TIME COORDINATION EXAMPLE

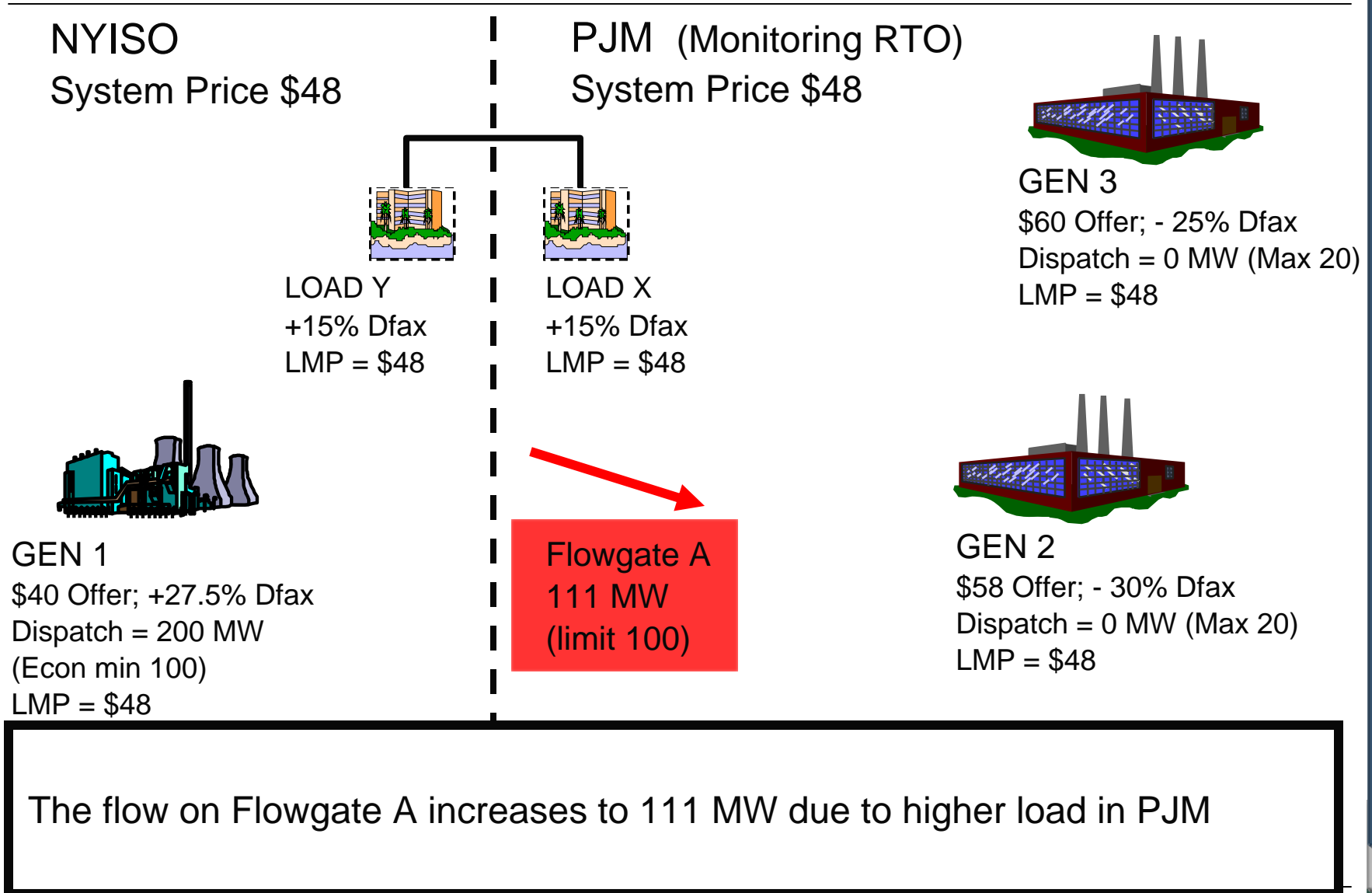


# Market-to-Market Example – Stage 1



LOAD X (in PJM) and LOAD Y (in NYISO) are electrically close to each other and have the same impact on Flowgate A.  
The initial NYISO Market Flow on Flowgate A is 35 MW.

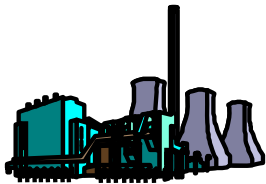
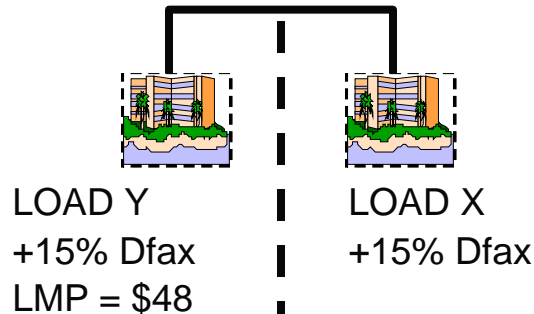
# Market-to-Market Example – Stage 2a



# Market-to-Market Example – Stage 2b

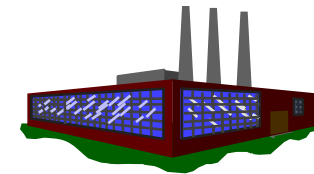
NYISO  
System Price \$48

PJM (Monitoring RTO)  
System Price \$48

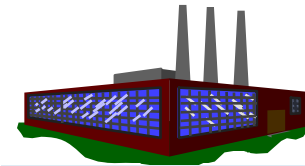


GEN 1  
\$40 Offer; +27.5% Dfax  
Dispatch = 200 MW  
(Econ min 100)  
LMP = \$48

Flowgate A  
111 MW  
(limit 100)



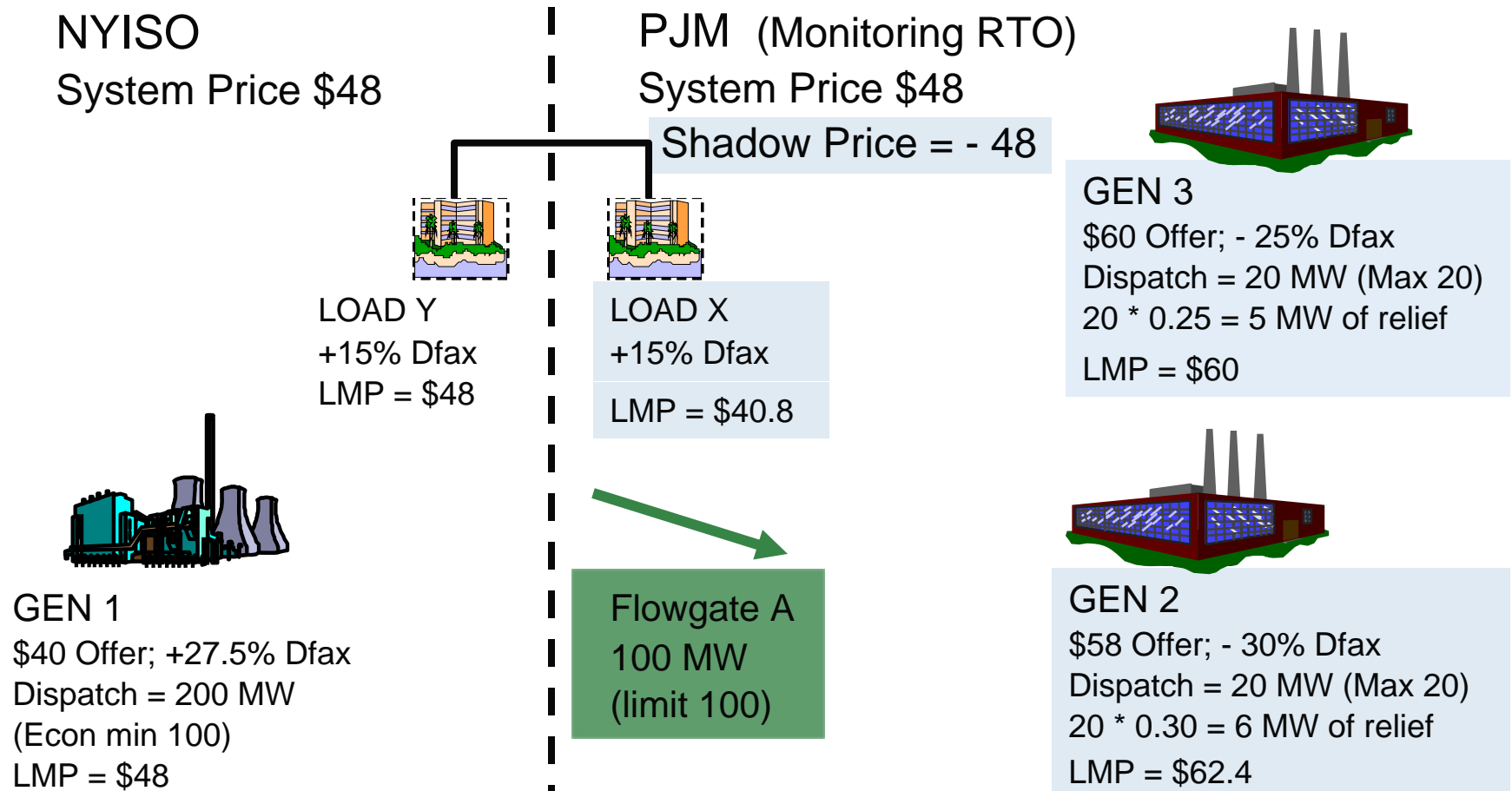
GEN 3  
\$60 Offer; - 25% Dfax  
Dispatch = 20 MW (Max 20)  
 $20 * 0.25 = 5$  MW of relief



GEN 2  
\$58 Offer; - 30% Dfax  
Dispatch = 20 MW (Max 20)  
 $20 * 0.30 = 6$  MW of relief

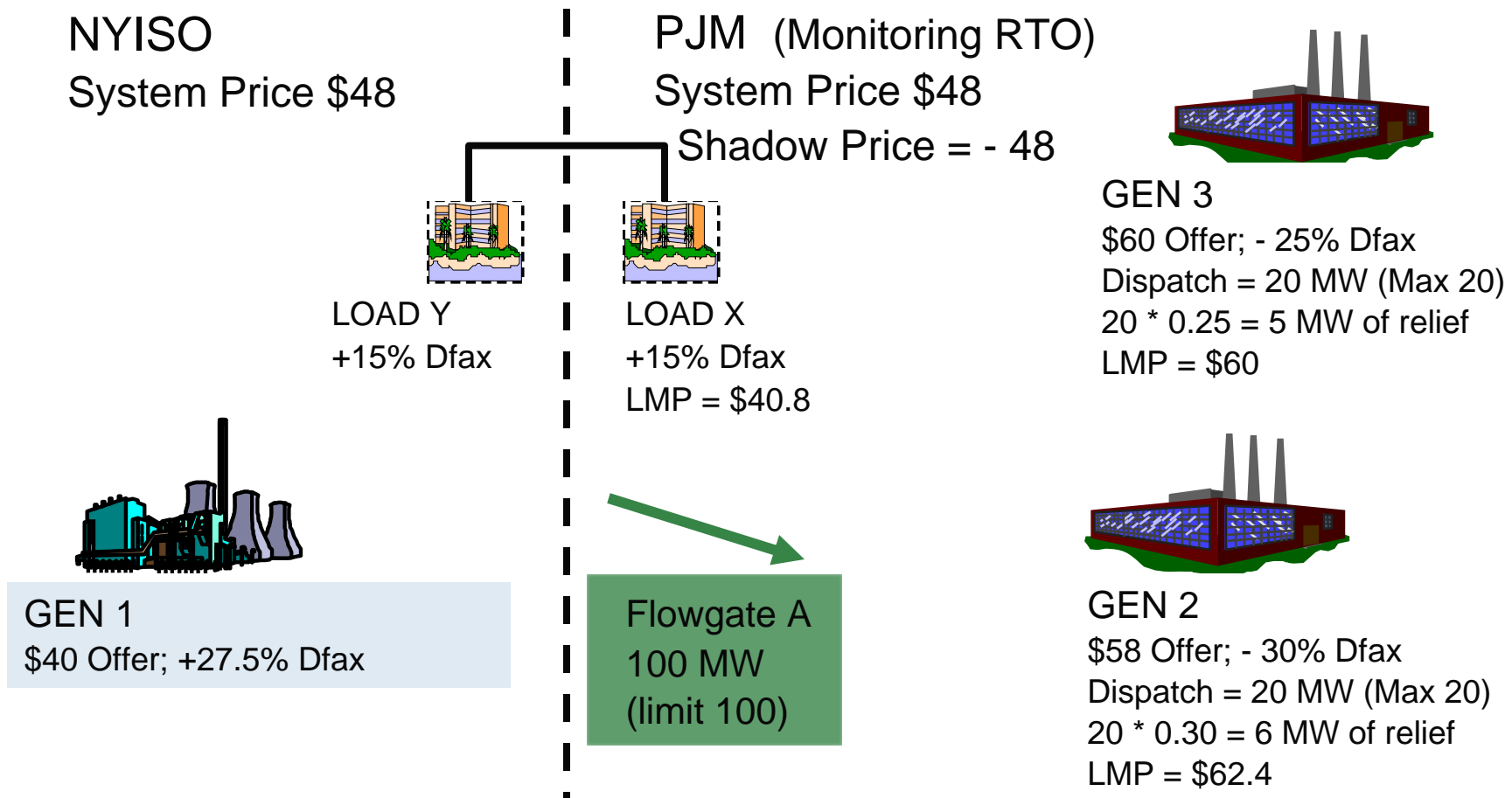
PJM dispatches GEN 2 and GEN 3 to control the Flowgate A

# Market-to-Market Example – Stage 2c



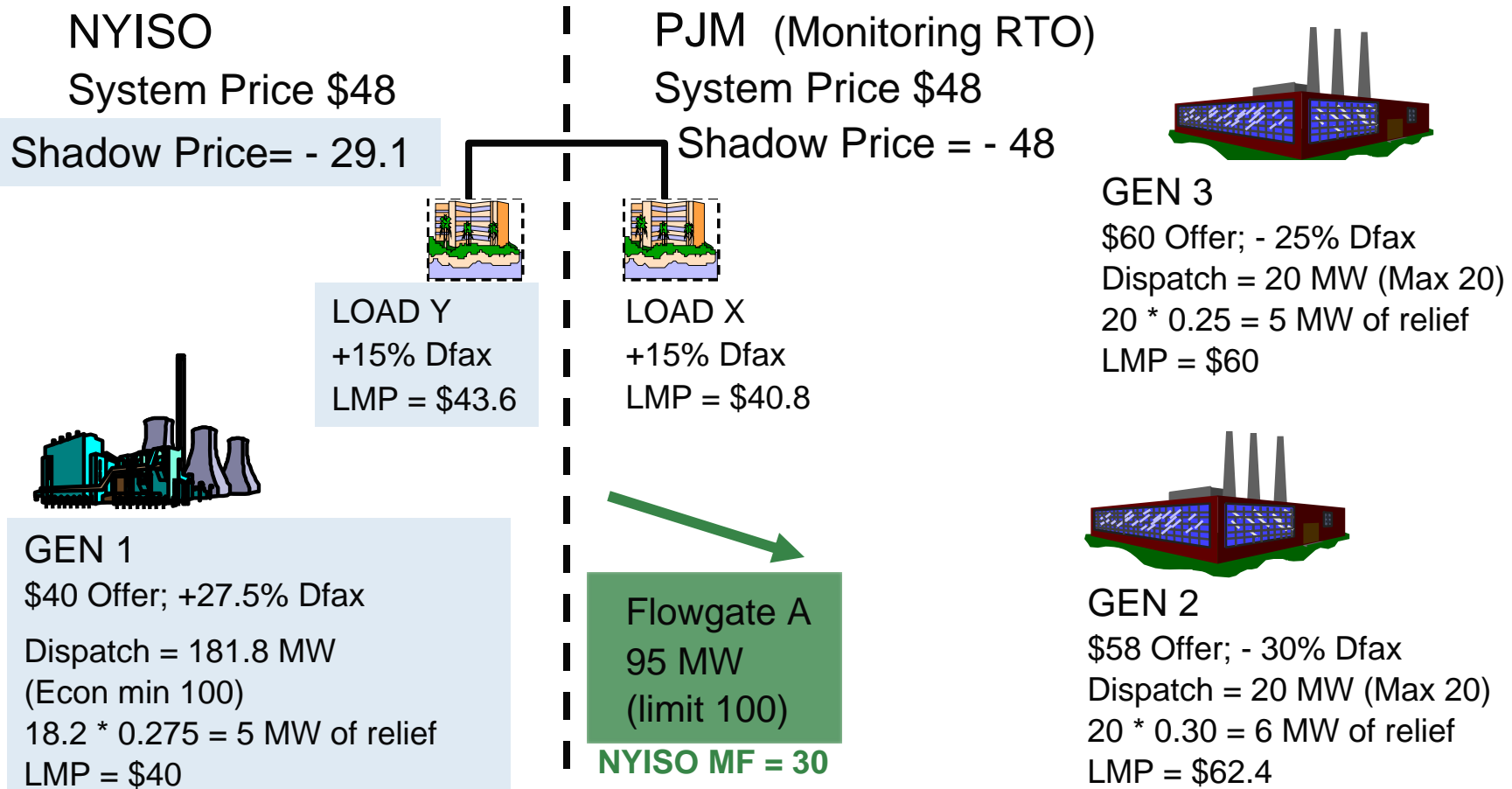
PJM dispatches GEN 2 and GEN 3 to control the Flowgate A  
 GEN 3 is the marginal unit and constraint shadow price is  $(60-48)/(-.25) = -48$   
 GEN 2 LMP =  $48 + (-0.30 * -48) = \$62.4$ ; LOAD X LMP =  $48 + (0.15 * -48) = \$40.8$

# Market-to-Market Example – Stage 3a



PJM notifies NYISO to invoke M2M to control Flowgate A.  
 PJM requests 5 MW of relief at the current shadow price of -48.  
 NYISO reduces GEN 1 to provide the relief requested by PJM

# Market-to-Market Example – Stage 3b



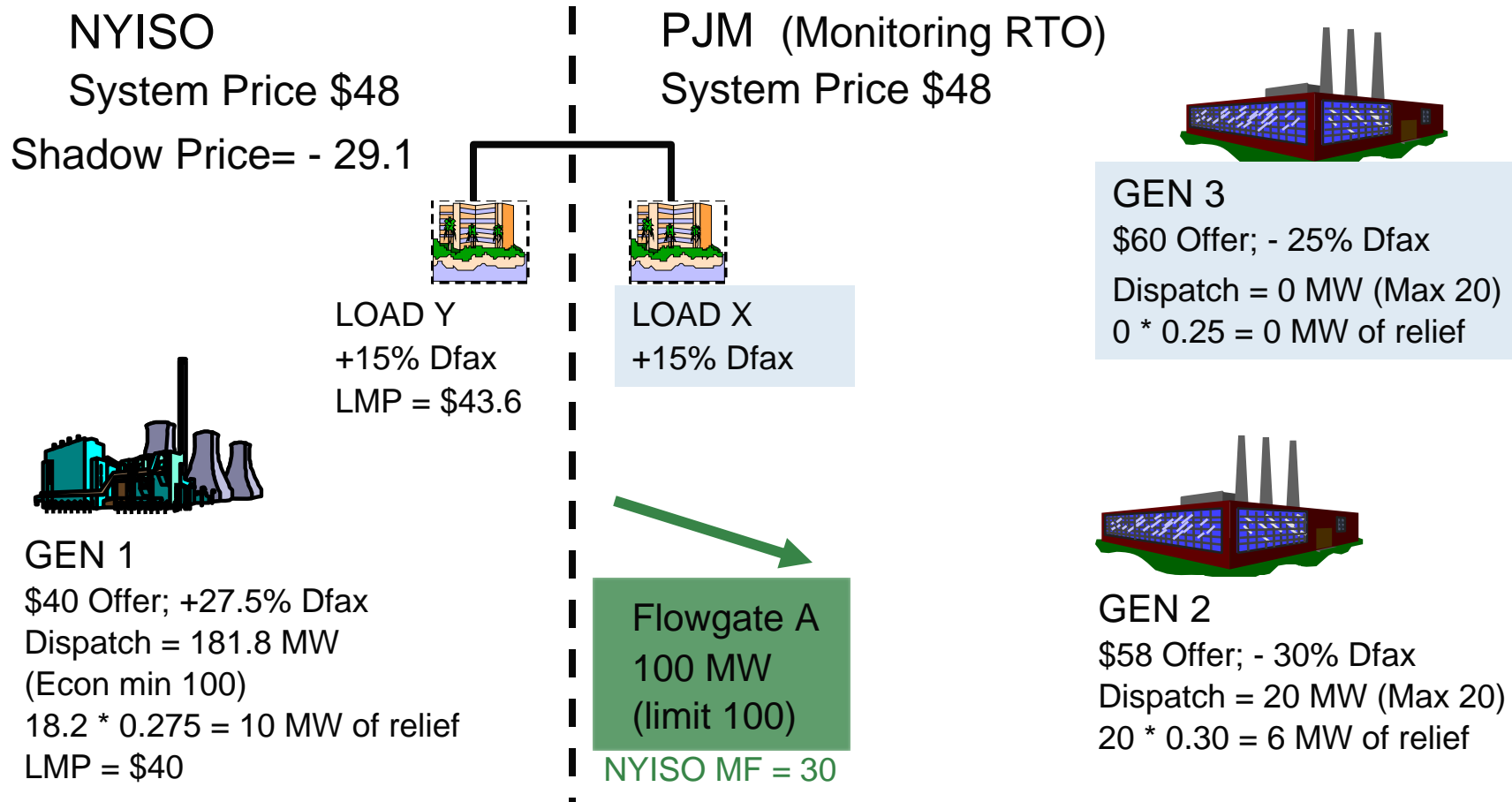
GEN 1 is reduced by 18.2 MW (to 181.8 MW) to provide 5 MW of relief.

NYISO constraint shadow price is  $(40 - 48) / 0.275 = - 29.1$

LOAD Y LMP =  $48 + (0.15 * - 29.1) = 43.6$  ; **NYISO MF decreases to 30**



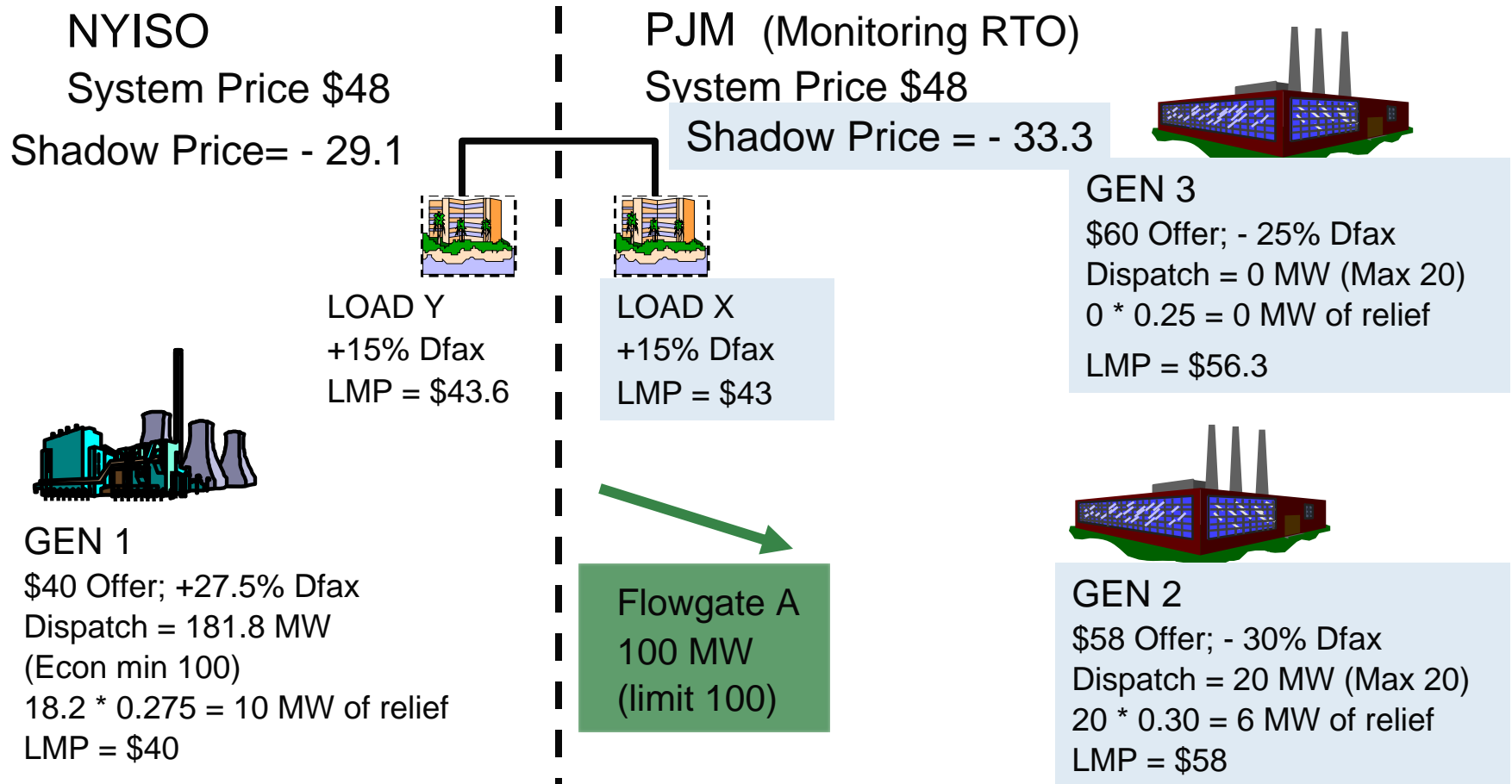
# Market-to-Market Example – Stage 4a



With loading decreases on Flowgate A, PJM can release the less cost-effective GEN 3.

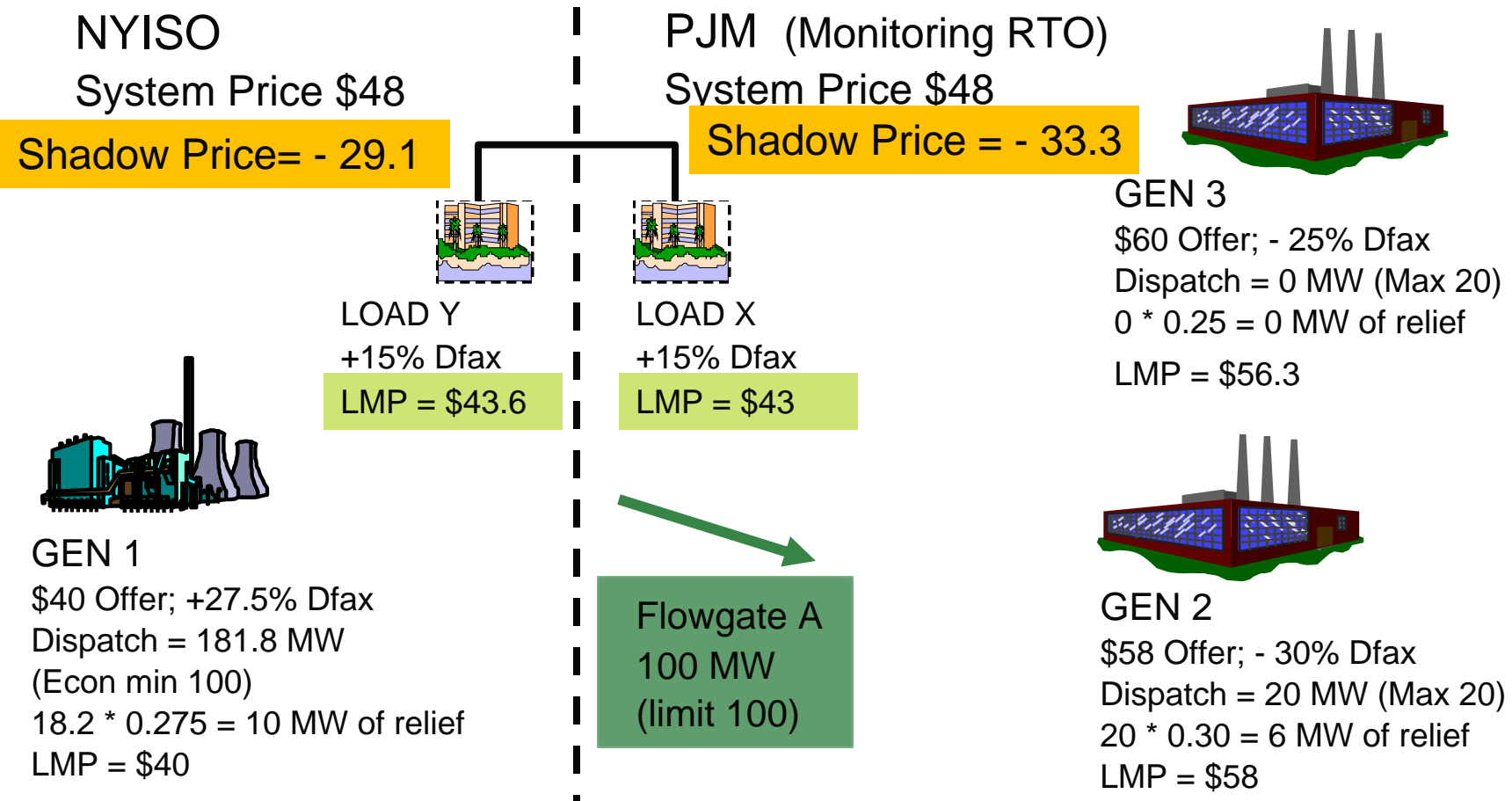
$-20 * -0.25 = 5$  MW of flow is added back to Flowgate A which is now at its limit.

# Market-to-Market Example – Stage 4b



With GEN 3 offline, GEN 2 becomes the new marginal unit for the constraint  
 Constraint shadow price is  $(58 - 48) / (- 0.30) = - 33.3$   
 GEN 3 LMP =  $48 + (-0.25 * -33.3) = 56.3$ ; LOAD X LMP =  $48 + (0.15 * -33.3) = 43$

# Market-to-Market Example – Stage 4b



Note the constraint shadow price convergence between PJM and NYISO and the LMP convergence between LOAD X (in PJM) and LOADY (in NYISO).

---

# MARKET FLOW CALCULATION EXAMPLE



# Market Flow Calculation

---

- Market Flow =  $\text{Sum}(\text{GLDF} * \text{Gen}) + \text{Sum}(\text{TDF} * \text{Transfer}) + \text{Sum}(\text{PAR Redirects})$

where:

$\text{GLDF} = \text{GSF}_{\text{Gen}} - \text{LDF}_{\text{Area}}$ , for a M2M Flowgate

$\text{TDF} = \text{GSF}_{\text{Area}} - \text{LDF}_{\text{Area}}$ , for a M2M Flowgate

PAR Redirect =

$(\text{Sum}(\text{GLDF}(\text{PAR}) * \text{Gen}) + \text{Sum}(\text{TDF}(\text{PAR}) * \text{Transfer})) - ((\text{Desired PAR flow} - \text{Actual PAR flow}) * \text{PAR DF})$ ,  
for a M2M Flowgate

# Market Flow Calculation

---

- Market Flow is the impact one market area has on a flowgate.
- Market Flow includes impacts
  - Gen-to-Load impacts: generators serving load
  - Transfer Impacts: interchange
  - Recognizes “PAR Redirect”
- Market Flow =  
Gen-to-Load + Transfers + PAR Redirect

# Market Flow Calc: GLDF

---

- Gen-to-Load Distribution Factor (GLDF)
- GLDF is a distribution factor calculated from one generator to a weighted average load shift factor
- Shift Factors for a Flowgate
  - Unit 1 GSF: -0.146
  - Load 1 LSF: -0.104
- Distribution Factor for a Flowgate
  - $GLDF = (-0.146) - (-0.104) = -0.042$

# Market Flow Calc: TDF

---

- Transfer Distribution Factor: TDF
- TDF = Weighted generation in one area to weighted load in another area =  $GSF_{Area} - LSF_{Area}$
- TDF applies between areas
- Internal to a market (control zone transfers)
- Interchange transactions between a market and other areas (eTags)



---

# SETTLEMENT EXAMPLE



# Settlement Algorithm

---

The settlement for each M2M flowgate will be calculated based on the following equation:

- $\text{Settlement}_i = (\text{MF}_i - \text{Ent}_i) \times \text{Shad}_i \times s_i / 3600$

Where:

$\text{Settlement}_i$  = Settlement for interval<sub>*i*</sub> .

- A positive value indicates a payment from the NMRTO to the MRTO.
- A negative value indicates a payment from the MRTO to the NMRTO.

# Settlement Algorithm (Cont.)

---

Other Definitions:

$MF_i$  = Real-Time Market Flow for interval<sub>*i*</sub> .

$Ent_i$  = M2M Entitlement for interval<sub>*i*</sub> .

$Shad_i$  = ex-ante Constraint Shadow Price for interval<sub>*i*</sub> .

$s_i$  = Number of seconds for interval<sub>*i*</sub> .

Each interval will be calculated separately and then summed to hourly and daily values for this M2M flowgate and repeated for all M2M flowgates.

# Real-Time Coordination Example

---

$$MF_i = 25 \text{ MW}$$

$$Ent_i = 35 \text{ MW}$$

$$Shad_i = \$40 \text{ (Shadow price of NMRTO)}$$

$$S_i = 300$$

$$\begin{aligned} \text{Settlement}_i &= (25 - 35) \times 40 \times 300/3600 \\ &= -\$33.33 \end{aligned}$$

This will be paid from PJM (MRTO) to the NYISO (NMRTO).

# Invoicing

---

- M2M Coordination Settlements will be invoiced weekly by the NYISO for the previous week.