# Energy Imbalance Market Technical Workshop

## Flexible Ramp Capacity Constraints
## September 17, 2013
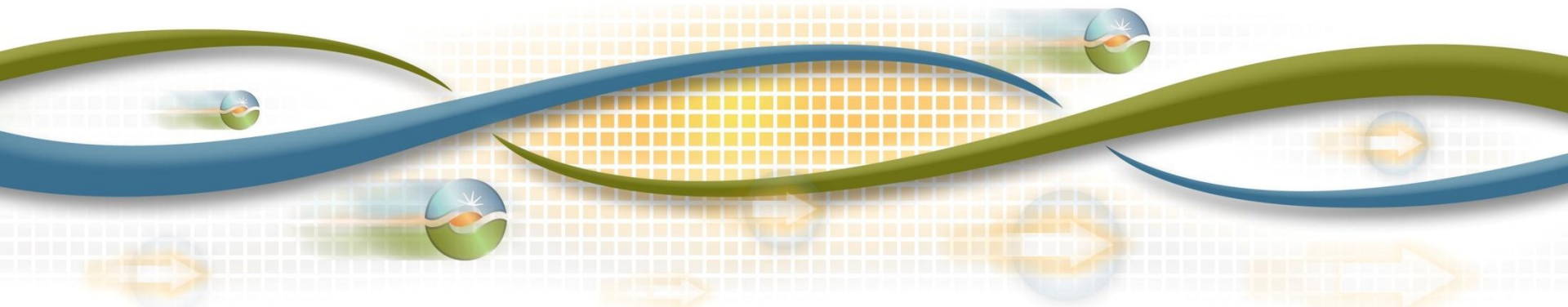
# Overview

- Flexible ramp sufficiency test
- Flexible ramp capacity constraints
  - When flexible ramp sufficiency test fails
  - When flexible ramp sufficiency test passes

# Changes from Last Workshop

- Added a requirement credit in the flexible ramp sufficiency test for any net outgoing EIM transfer before the start of the hour
  - ◆ Outgoing EIM transfer can be reduced to meet flexible ramp capacity requirements
- Used available net import capability to reduce requirements in the flexible ramp capacity constraints instead of available intertie capacity
  - ◆ To allow loop flow through EIM Entity BAAs that fail the flexible ramp sufficiency test

# Flexible Ramp Sufficiency Test

- **Performed for each EIM Entity BAA**
  - After $T-75'$, $T-55'$, and $T-40'$ for the Trading Hour starting at $T$
- **Data used:**
  - Initial schedules at $T-7.5'$
  - EIM resources energy bids and ramp rates
  - 15' Flexible ramp requirements
    - reduced by any prorated EIM diversity benefit
    - reduced by any net outgoing EIM transfer at $T-7.5'$
    - reductions limited by the available net import capability

# Flexible Ramp Sufficiency Test

- Cumulative test for meeting flexible ramp requirements for each 15' interval of the hour
  - 15' ramp from $T-7.5'$ to $T+7.5'$ (1st 15' interval)
  - 30' ramp from $T-7.5'$ to $T+22.5'$ (2nd 15' interval)
  - 45' ramp from $T-7.5'$ to $T+37.5'$ (3rd 15' interval)
  - 60' ramp from $T-7.5'$ to $T+52.5'$ (4th 15' interval)
- Test passes if <u>all</u> four cumulative tests pass
- Test fails if <u>any</u> of the four cumulative tests fail
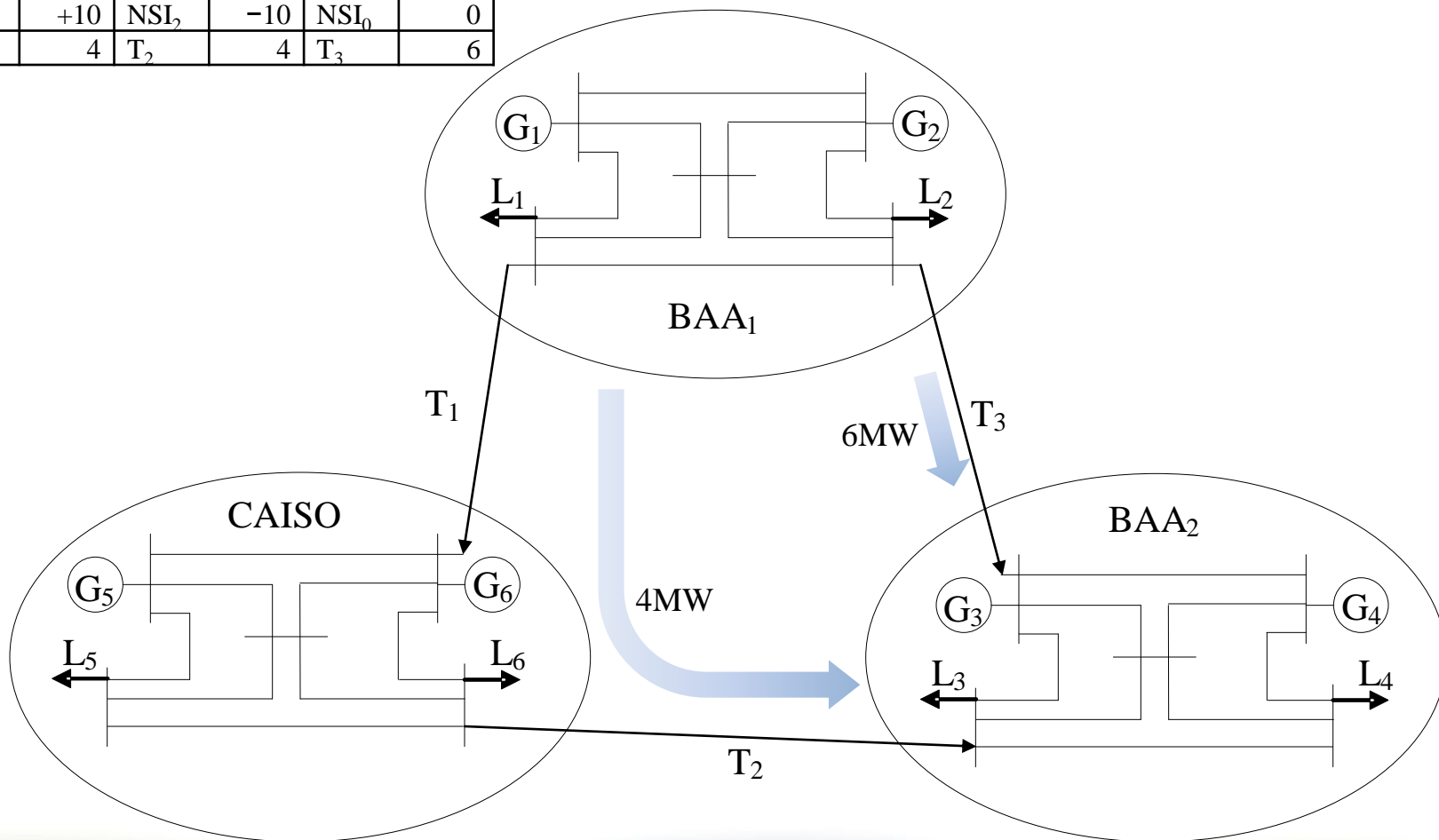
# Flexible Ramp Capacity Constraints

- **EIM Entity BAA that fails the test**
  - Excluded from group constraints
  - Net import interchange is capped at last 15-min schedule before the hour (at $T-7.5'$)
- **EIM Entity BAAs that pass the test**
  - Bottom-up hierarchical constraints for all BAA combinations
  - BAA group requirement is reduced by the available net import capability into the BAA group

# Example Assumptions

- CAISO BAA and two EIM Entity BAAs

- All interties rated at 10MW

- Two generators and two loads in each BAA

- Zero base schedules; no transmission losses

- Real−Time Unit Commitment run at $T$−37.5'

- Only upward flexible ramp capacity

- Flexible ramp capacity requirement determined solely by demand forecast change

# Example

| 15' Schedules at $T-7.5'$ | | | | | |
|---|---|---|---|---|---|
| **BAA$_1$** | | **BAA$_2$** | | **CAISO** | |
| G$_1$ | 60 | G$_3$ | 10 | G$_5$ | 100 |
| G$_2$ | 50 | G$_4$ | 80 | G$_6$ | 100 |
| L$_1$ | 40 | L$_3$ | 30 | L$_5$ | 100 |
| L$_2$ | 60 | L$_4$ | 70 | L$_6$ | 100 |
| NSI$_1$ | +10 | NSI$_2$ | −10 | NSI$_0$ | 0 |
| T$_1$ | 4 | T$_2$ | 4 | T$_3$ | 6 |

# Available Flexible Ramp Capacity

| BAA | Resource | Initial Schedule | UEL | Ramp Rate | 15' FRC | 30' FRC | 45' FRC | 60' FRC |
|---|---|---|---|---|---|---|---|---|
| BAA$_1$ | G$_1$ | 60 | 100 | 1 | 15 | 30 | 40 | 40 |
| | G$_2$ | 50 | 100 | 1 | 15 | 30 | 45 | 50 |
| | *Total* | 110 | 200 | | 30 | 60 | 85 | 90 |
| BAA$_2$ | G$_3$ | 10 | 100 | 1 | 15 | 30 | 45 | 60 |
| | G$_4$ | 80 | 100 | 1 | 15 | 20 | 20 | 20 |
| | *Total* | 90 | 200 | | 30 | 50 | 65 | 80 |

# Case 1: Flexible Ramp Sufficiency Test Pass

| BAA | | T-7.5' | T+7.5' | T+22.5' | T+37.5' | T+52.5' |
|---|---|---|---|---|---|---|
| CAISO | Total CAISO load | 200 | 220 | 210 | 200 | 190 |
| | Cumulative flexible ramp requirement | | 20 | 10 | 0 | 0 |
| BAA$_1$ | $L_1 + L_2$ | 100 | 120 | 140 | 160 | 180 |
| | EIM diversity benefit | | 0 | 0 | 0 | −5 |
| | Flexible ramp requirement credit | | −10 | −10 | −10 | −10 |
| | Cumulative flexible ramp requirement | | 10 | 30 | 50 | 65 |
| | Cumulative flexible ramp capacity | | 30 | 60 | 85 | 90 |
| | Flexible ramp sufficiency test outcome | | ✓ | ✓ | ✓ | ✓ |
| BAA$_2$ | $L_3 + L_4$ | 100 | 120 | 140 | 160 | 180 |
| | EIM diversity benefit | | 0 | 0 | 0 | −5 |
| | Cumulative flexible ramp requirement | | 20 | 40 | 60 | 75 |
| | Cumulative flexible ramp capacity | | 30 | 50 | 65 | 80 |
| | Flexible ramp sufficiency test outcome | | ✓ | ✓ | ✓ | ✓ |
| EIM | Total EIM load | 400 | 460 | 490 | 520 | 550 |
| | Cumulative flexible ramp requirement | | 60 | 90 | 120 | 150 |
| | Sum of BAA flexible ramp requirement | | 60 | 90 | 120 | 160 |

# Case 1: Flexible Ramp Capacity Constraints

- **For *T*+7.5'**
  - ◆ $FRC_0 \geq \max(0, FRR_0 - 20) = 0$
  - ◆ $FRC_1 \geq \max(0, FRR_1 - 30) = 0$
  - ◆ $FRC_2 \geq \max(0, FRR_2 - 10) = 10$
  - ◆ $FRC_0 + FRC_1 \geq \max(0, FRR_{0,1} - 30) = 10$
  - ◆ $FRC_0 + FRC_2 \geq \max(0, FRR_{0,2} - 10) = 30$
  - ◆ $FRC_1 + FRC_2 \geq \max(0, FRR_{1,2} - 20) = 20$
  - ◆ $FRC_0 + FRC_1 + FRC_2 \geq FRR_{0,1,2} = 60$

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# Case 2: Flexible Ramp Sufficiency Test Fail

| BAA | | T-7.5' | T+7.5' | T+22.5' | T+37.5' | T+52.5' |
|---|---|---|---|---|---|---|
| CAISO | Total CAISO load | 200 | 220 | 210 | 200 | 190 |
| | Cumulative flexible ramp requirement | | 20 | 10 | 0 | 0 |
| BAA$_1$ | L$_1$ + L$_2$ | 100 | 120 | 140 | 160 | 180 |
| | EIM diversity benefit | | 0 | 0 | 0 | −5 |
| | Flexible ramp requirement credit | | −10 | −10 | −10 | −10 |
| | Cumulative flexible ramp requirement | | 10 | 30 | 50 | 65 |
| | Cumulative flexible ramp capacity | | 30 | 60 | 85 | 90 |
| | Flexible ramp sufficiency test outcome | | ✓ | ✓ | ✓ | ✓ |
| BAA$_2$ | L$_3$ + L$_4$ | 100 | 120 | 150 | 170 | 180 |
| | EIM diversity benefit | | 0 | 0 | 0 | −5 |
| | Cumulative flexible ramp requirement | | 20 | 50 | 70 | 75 |
| | Cumulative flexible ramp capacity | | 30 | 50 | 65 | 80 |
| | Flexible ramp sufficiency test outcome | | ✓ | ✓ | ✗ | ✓ |
| EIM | Total EIM load | 400 | 460 | 500 | 530 | 550 |
| | Cumulative flexible ramp requirement | | 60 | 100 | 130 | 150 |
| | Sum of BAA flexible ramp requirement | | 60 | 100 | 130 | 160 |

# Case 2: Flexible Ramp Capacity Constraints

- ## For $T+7.5'$

  - $FRC_0 \geq \max(0, FRR_0 - 20) = 0$

  - $FRC_1 \geq \max(0, FRR_1 - 30) = 0$

  - $FRC_2 \geq FRR_2 = 20$

  - $FRC_0 + FRC_1 \geq FRR_{0,1} = 40$

  - $NSI_2 \geq -10$