Energy Imbalance Market Technical Workshop

BAA Real-Time Congestion Balancing Account

August 12, 2013
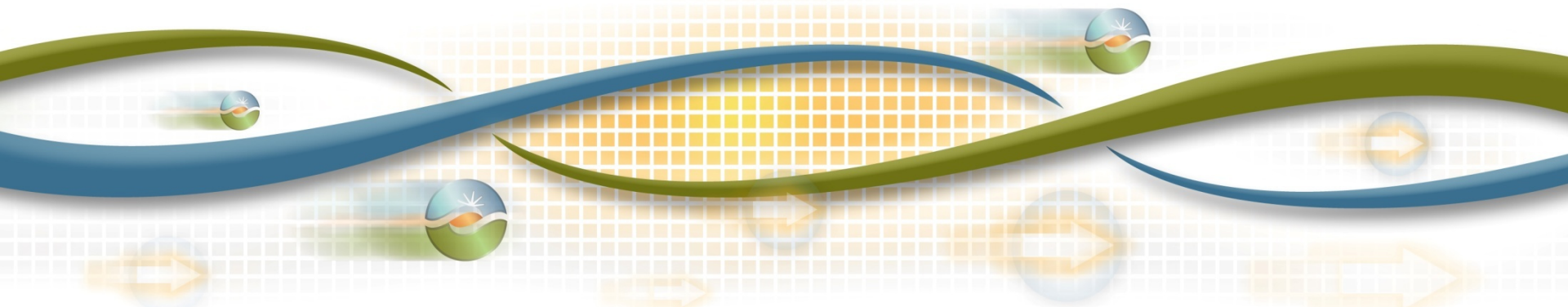
Overview

- BAA Real-Time Congestion Balancing Account
- Real−Time Convergence Bid Settlement

BAA Real-Time Congestion Balancing Account

- Calculate total real−time neutrality amount by BAA
  - Net of all imbalance energy settlements
    - 15−min and 5−min Instructed Energy settlement
      - Generating/intertie resources, participating load, NGR
    - Uninstructed Imbalance Energy settlement
      - Non−participating load (hourly)
      - Generating/intertie resources, participating load, NGR (5−min)
    - Unaccounted For Energy (5−min)
- Extract congestion offset by BAA
  - Net of marginal congestion cost contributions from all binding constraints in a BAA to all imbalances
- Allocate congestion offset to respective BAA

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Example Assumptions

- CAISO BAA and two EIM BAAs
- Two generators and two loads in each BAA
- No Day-Ahead Market schedules
- No base schedules
- Single Real-Time Market interval: one hour
- No transmission losses
- Transmission Congestion in each BAA
- Generator meter equals schedule
- LMPs are indicative (no OPF solver)

BAA$_1$		BAA$_2$		CAISO	
G$_1$	80	G$_3$	60	G$_5$	60
G$_2$	50	G$_4$	90	G$_6$	60
L$_1$	40	L$_3$	30	L$_5$	100
L$_2$	60	L$_4$	70	L$_6$	100
NSI$_1$	+30	NSI$_2$	+50	NSI$_0$	−80
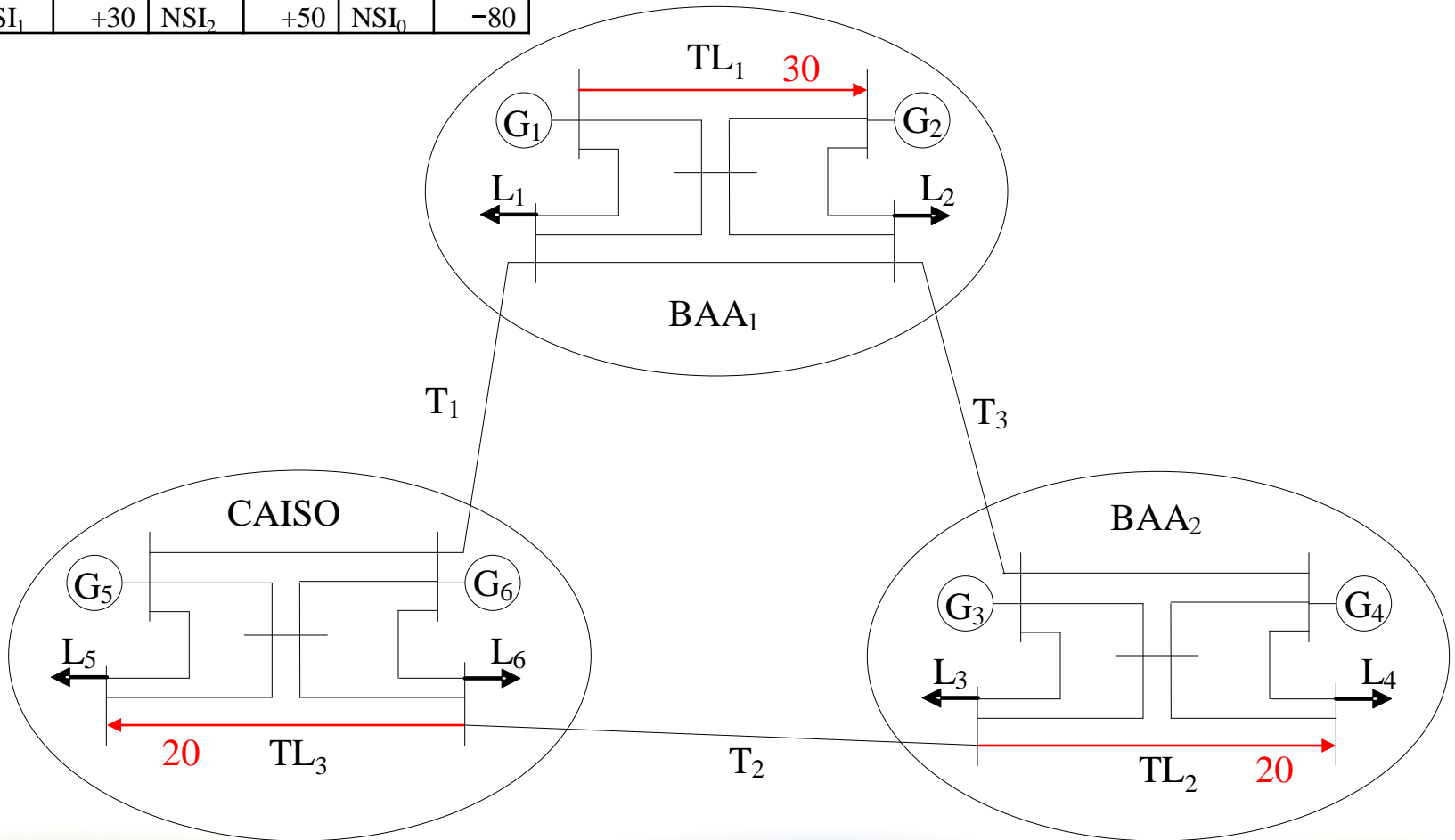
Shift Factors and Power Flow Contributions

Resource	Schedule	TL$_1$		TL$_2$		TL$_3$	
		SF	Flow	SF	Flow	SF	Flow
G$_1$	80	0.70	56.00	0.02	1.60	0.02	1.60
G$_2$	50	−0.60	−30.00	0.03	1.50	0.08	4.00
L$_1$	−40	0.40	−16.00	0.04	−1.60	0.05	−2.00
L$_2$	−60	−0.35	21.00	0.05	−3.00	0.20	−12.00
G$_3$	60	−0.20	−12.00	0.13	7.80	0.03	1.80
G$_4$	90	−0.15	−13.50	−0.20	−18.00	0.00	0.00
L$_3$	−30	0.05	−1.50	0.31	−9.30	0.10	−3.00
L$_4$	−70	0.00	0.00	−0.64	44.80	0.02	−1.40
G$_5$	60	0.20	12.00	0.02	1.20	−0.20	−12.00
G$_6$	60	0.30	18.00	0.05	3.00	0.40	24.00
L$_5$	−100	0.00	0.00	0.00	0.00	−0.60	60.00
L$_6$	−100	0.04	−4.00	0.08	−8.00	0.41	−41.00
Total	0		30.00		20.00		20.00

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Marginal Congestion Cost Contributions

Res	Sch	TL$_1$			TL$_2$			TL$_3$		
		SF	SP	MCC	SF	SP	MCC	SF	SP	MCC
G$_1$	80	0.70		$560	0.02		$32	0.02		$48
G$_2$	50	−0.60		−$300	0.03		$30	0.08		$120
L$_1$	−40	0.40		−$160	0.04		−$32	0.05		−$60
L$_2$	−60	−0.35		$210	0.05		−$60	0.20		−$360
G$_3$	60	−0.20		−$120	0.13		$156	0.03		$54
G$_4$	90	−0.15	$10	−$135	−0.20	$20	−$360	0.00	$30	$0
L$_3$	−30	0.05		−$15	0.31		−$186	0.10		−$90
L$_4$	−70	0.00		$0	−0.64		$896	0.02		−$42
G$_5$	60	0.20		$120	0.02		$24	−0.20		−$360
G$_6$	60	0.30		$180	0.05		$60	0.40		$720
L$_5$	−100	0.00		$0	0.00		$0	−0.60		$1,800
L$_6$	−100	0.04		−$40	0.08		−$160	0.41		−$1,230
Total	0			$300			$400			$600

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Imbalance Energy Settlement

Res	Sch	MEC	TL$_1$		TL$_2$		TL$_3$		LMP	Payment
			SF	SP	SF	SP	SF	SP		
G$_1$	80		0.70		0.02		0.02		$42.00	$3,360
G$_2$	50		−0.60		0.03		0.08		$53.00	$2,650
L$_1$	−40		0.40		0.04		0.05		$43.70	-$1,748
L$_2$	−60		−0.35		0.05		0.20		$46.50	-$2,790
G$_3$	60		−0.20		0.13		0.03		$48.50	$2,910
G$_4$	90	$50	−0.15	$10	−0.20	$20	0.00	$30	$55.50	$4,995
L$_3$	−30		0.05		0.31		0.10		$40.30	-$1,209
L$_4$	−70		0.00		−0.64		0.02		$62.20	-$4,354
G$_5$	60		0.20		0.02		−0.20		$53.60	$3,216
G$_6$	60		0.30		0.05		0.40		$34.00	$2,040
L$_5$	−100		0.00		0.00		−0.60		$68.00	-$6,800
L$_6$	−100		0.04		0.08		0.41		$35.70	-$3,570
Total	0									-$1,300

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BAA Real Time Congestion Balancing Account results

- BAA$_1$ congestion uplift on TL$_1$: $300

- BAA$_2$ congestion uplift on TL$_2$: $400

- ISO congestion uplift on TL$_3$: $600

Physical and Virtual Base Schedule Flow Impact on EIM Constraint
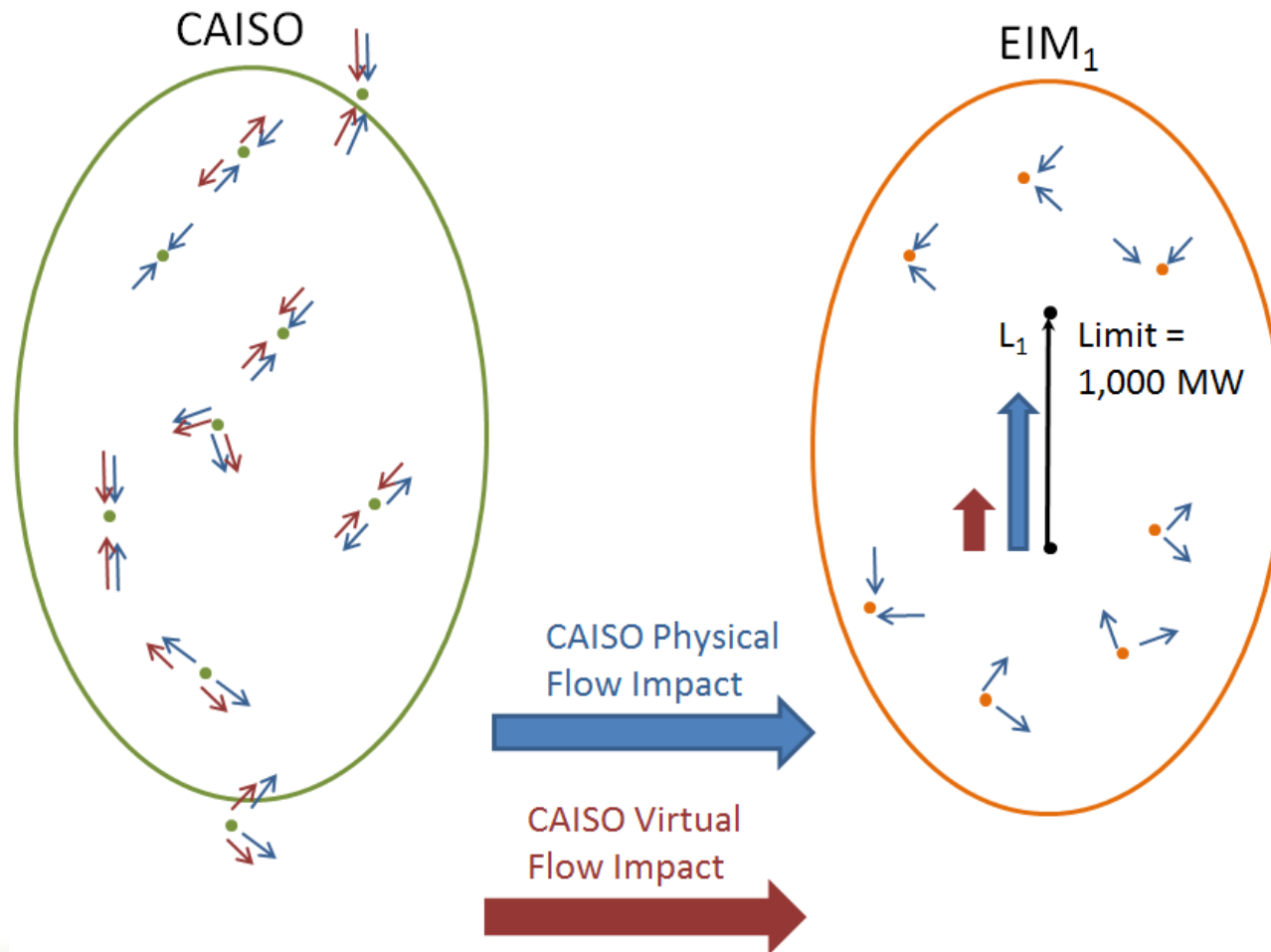
Define BAA Real-Time Congestion Balancing Account by Flow Impact

$$RTCBA_L^{15\min} = -\lambda_L^{15\min} \sum_n \left[SF_{n,L}^{15\min} \left(Q_n^{15\min} - Q_n^{Base} \right) \right]$$

$$= \lambda_L^{15\min} \left[FI_L^{Base} - FI_L^{15\min} \right]$$

Where

$\lambda_L^{15\min}$ is the shadow price of constraint L in 15 - minute market.

$SF_{n,L}^{15\min}$ is the shift factor of node n with respect to constraint L in the 15 - minute market.

$Q_n^{15\min}$ is the net scheduled MW at node n in the 15 - minute market. Negative $Q_n^{15\min}$ is
a withdrawal.

Q_n^{Base} is the net scheduled base MW, including both virtual and physical schedules,
at node n. Base MWs for EIM BAs is the base schedule. Base MWs for
CAISO is the IFM schedule.

$FI_L^{15\min}$ is the total scheduled flow impact on constraint L from 15 - minute market schedules.

FI_L^{Base} is the total scheduled flow impact on constraint L from base schedules.

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Define BAA Real-Time Congestion Balancing Account by Physical and Virtual Flow Impact

$$RTCBA_L^{15\min} = \lambda_L^{15\min}\left[FI_L^{Base} - FI_L^{15\min}\right]$$
$$= \lambda_L^{15\min}\left[\left(FI_L^{Base:Physical} + FI_L^{Base:Virtual}\right) - FI_L^{15\min}\right]$$
$$= \lambda_L^{15\min}\left[FI_L^{Base:Physical} - FI_L^{15\min}\right] + \lambda_L^{15\min}\left[FI_L^{Base:Virtual}\right]$$

■ **BAA Real-Time Congestion Balancing Account from constraint L is function of:**

◆ Change in scheduled physical flows between base and 15-minute schedules

◆ Change in scheduled virtual flows between base and 15-minute schedules

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Virtual Bid Revenue from Out-of-Market RT Congestion Uplift

Total Scheduled Flow Impact on Constraint
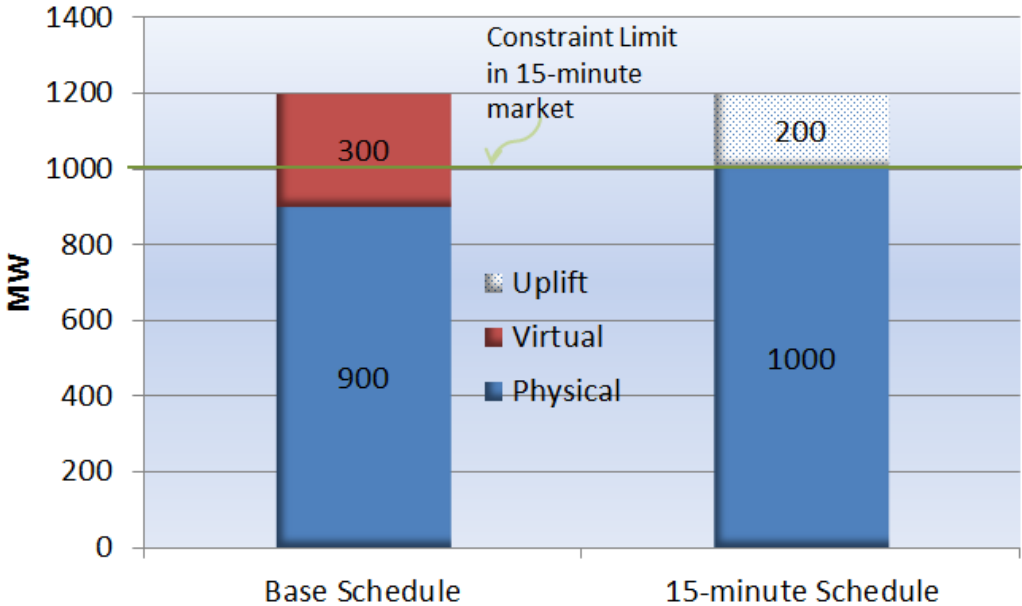
Base Virtual Flow Impact	Base Physical Flow Impact	15min Physical Flow Impact	Congestion Uplift	Virtual Revenue from L_1	Physical Revenue from L_1	Out-of-Market Virtual Revenue	Out-of-Market Physical Revenue
300 MW	900 MW	1,000 MW	200MW * λ^{15min}	300MW * λ^{15min}	-100MW * λ^{15min}	200MW * λ^{15min}	0

3rd Revised Straw Proposal: Virtual Allocation of BAA RT Congestion Balancing Account from EIM Entity Constraints

- Assign RT Congestion uplift from EIM BAA constraints into virtual bucket and physical bucket
  - In direct proportion to out-of-market congestion revenues received by virtual and physical schedules
- Allocate physical bucket to EIM Entity balancing account
- Allocate virtual bucket to virtual schedules
  - In proportion to each schedule's receipt of the out-of-market revenues
- Approach is only applied where there is an out of market charge
- RT congestion uplift allocation to virtual schedules for EIM-BA constraint L:

$$\lambda_L^{15\min} * \left(\max\left[0, \min\left(FI_L^{Base:Virtual}, \left[FI_L^{Base} - FI_L^{15\min} \right] \right) \right] \right)$$

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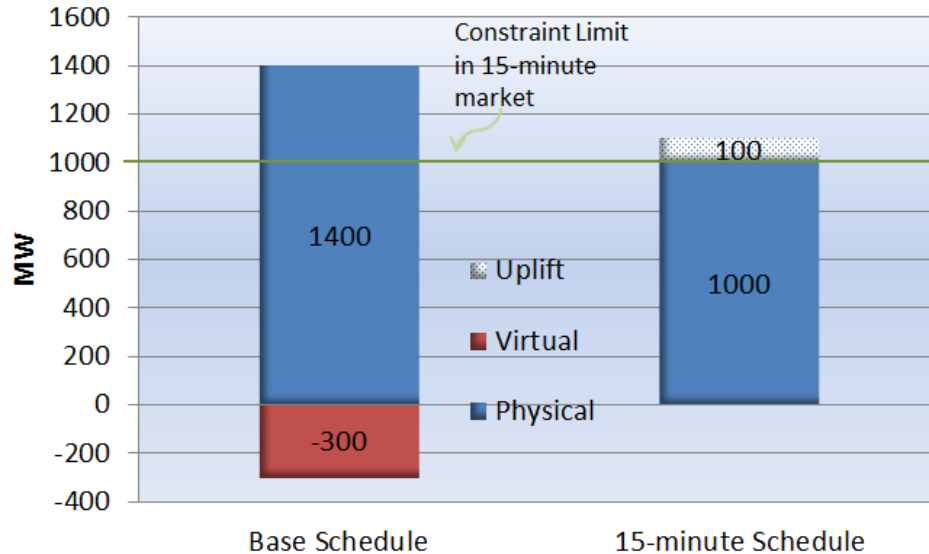# Problem with 2nd Revised Straw virtual settlement proposal

Total Scheduled Flow Impact on Constraint
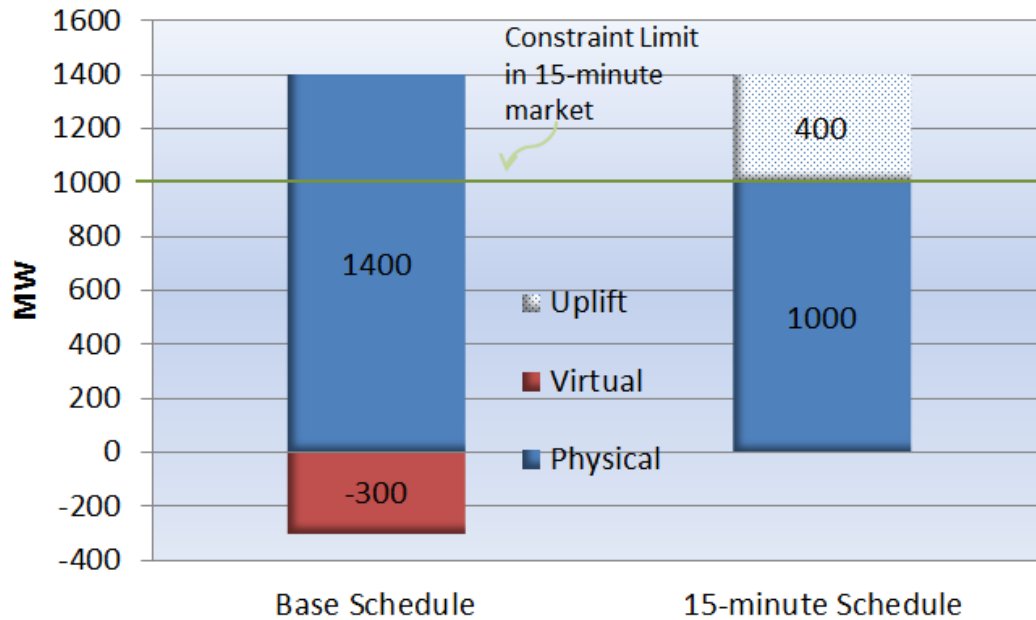
Base Virtual Flow Impact	Base Physical Flow Impact	15min Physical Flow Impact	Congestion Uplift	Virtual Revenue from L_1	Physical Revenue from L_1	Out-of-Market Virtual Revenue	Out-of-Market Physical Revenue
-300 MW	1,400 MW	1,000 MW	400MW * λ^{15min}	-300MW * $0	400MW * λ^{15min}	0	400MW * λ^{15min}

# Virtual Allocation Example: Virtual Counter-flow

Total Scheduled Flow Impact on Constraint

Virtual Allocation :

$$\lambda_L^{15\min} * \left(\max\left[0, \min\left(FI_L^{Base:Virtual}, \left[FI_L^{Base} - FI_L^{15\min} \right] \right) \right] \right)$$

Base Virtual Flow Impact	Base Physical Flow Impact	15min Physical Flow Impact	Congestion Uplift	Virtual Revenue from L₁	Physical Revenue from L₁	Out-of-Market Virtual Allocation	Out-of-Market Physical Allocation
-300 MW	1,400 MW	1,000 MW	100MW * $\lambda^{15\min}$	-300MW * $\lambda^{15\min}$	400MW * $\lambda^{15\min}$	0	100MW * $\lambda^{15\min}$

Virtual Allocation Example: Revenues > Allocation
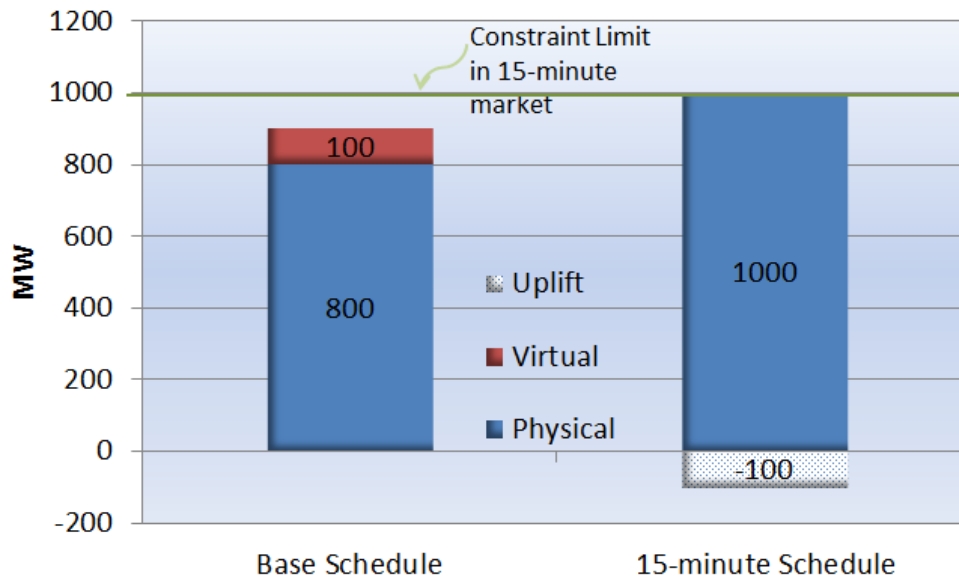

Total Scheduled Flow Impact on Constraint
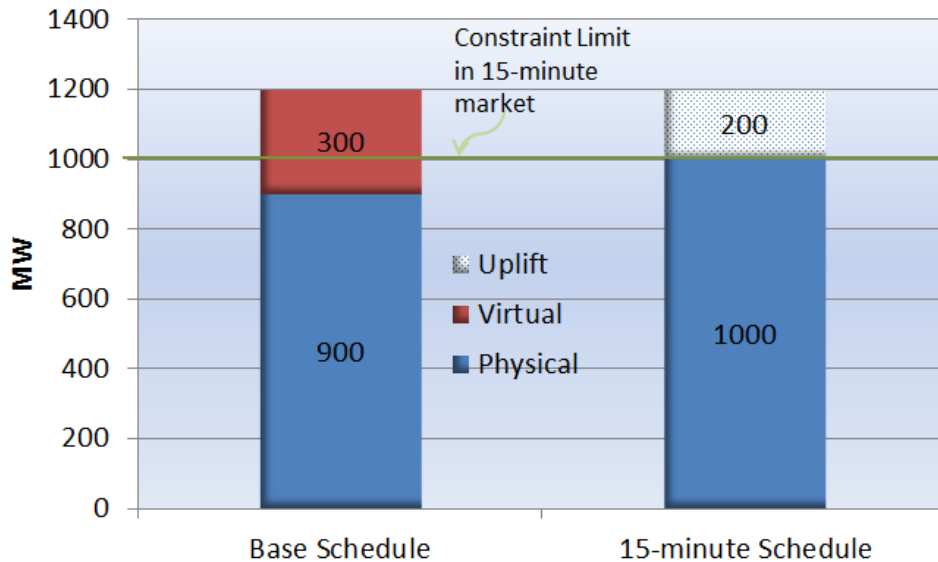
Virtual Allocation :

$$\lambda_L^{15min} *$$

$$\left(\max\left[0, \min\left(FI_L^{Base:Virtual}, \left[FI_L^{Base} - FI_L^{15min} \right] \right) \right] \right)$$

Base Virtual Flow Impact	Base Physical Flow Impact	15min Physical Flow Impact	Congestion uplift	Virtual Revenue from L_1	Physical Revenue from L_1	Out-of-Market Virtual Allocation	Out-of-Market Physical Allocation
300 MW	900 MW	1,000 MW	200MW * λ^{15min}	300MW * λ^{15min}	-100MW * λ^{15min}	200MW * λ^{15min}	0

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Virtual Allocation Example: Virtual Revenues with no Allocation

Total Scheduled Flow Impact on Constraint
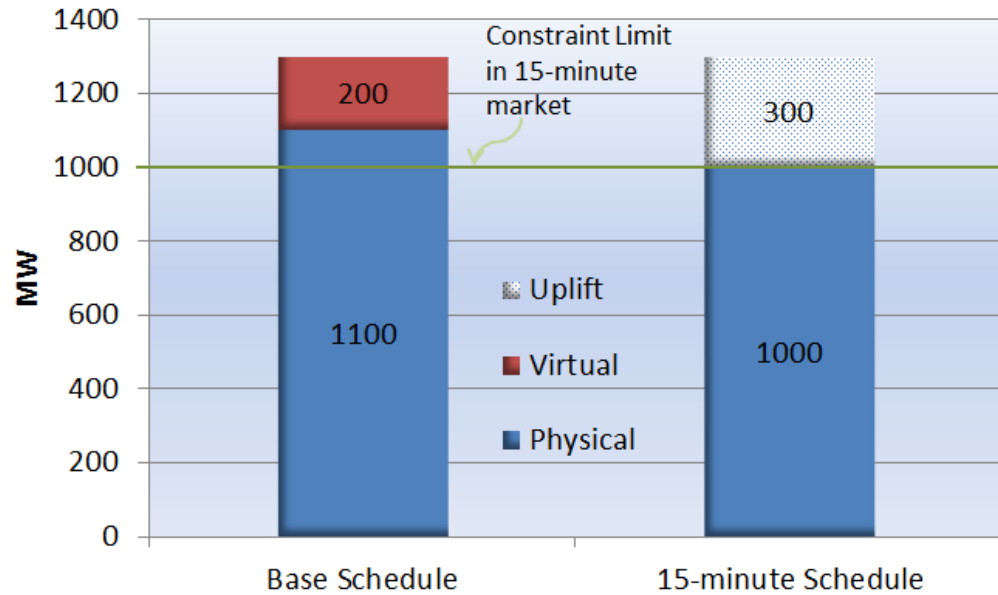

Virtual Allocation :

$$\lambda_L^{15\min} * \left(\max\left[0, \min\left(FI_L^{Base:Virtual}, \left[FI_L^{Base} - FI_L^{15\min} \right] \right) \right] \right)$$

Base Virtual Flow Impact	Base Physical Flow Impact	15min Physical Flow Impact	Congestion uplift	Virtual Revenue from L_1	Physical Revenue from L_1	Out-of-Market Virtual Allocation	Out-of-Market Physical Allocation
100 MW	800 MW	1,000 MW	-100MW * $\lambda^{15\min}$	100MW * $\lambda^{15\min}$	-200MW * $\lambda^{15\min}$	0	0

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Virtual Allocation Example: All Virtual Revenues Out-of-Market

Total Scheduled Flow Impact on Constraint

Virtual Allocation :

$$\lambda_L^{15\min} * \left(\max\left[0, \min\left(FI_L^{Base:Virtual}, \left[FI_L^{Base} - FI_L^{15\min}\right]\right)\right]\right)$$

Base Virtual Flow Impact	Base Physical Flow Impact	15min Physical Flow Impact	Congestion uplift	Virtual Revenue from L_1	Physical Revenue from L_1	Out-of-Market Virtual Allocation	Out-of-Market Physical Allocation
200 MW	1,100 MW	1,000 MW	300MW * $\lambda^{15\min}$	200MW * $\lambda^{15\min}$	100MW * $\lambda^{15\min}$	200MW * $\lambda^{15\min}$	100MW * $\lambda^{15\min}$

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