Contingency modeling enhancements discussion
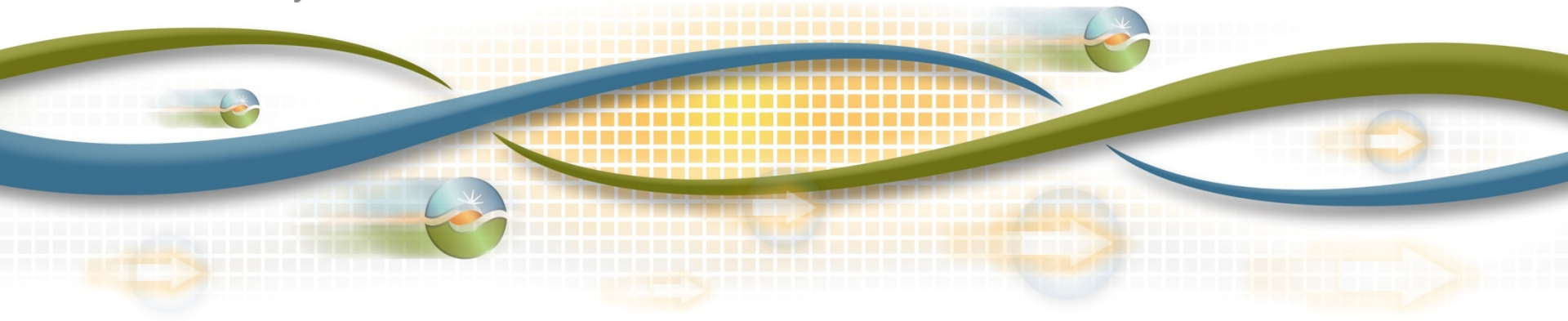
Existing CRR Revenue Inadequacy

Bradford Cooper

Manager, Market Design & Regulatory Policy

Market Surveillance Committee Meeting

General Session

February 11, 2016

Current CRR Revenue Inadequacy

Current causes of revenue inadequacy

- Difference in limits enforced in CRR market vs. DAM
- Difference in network topology in CRR market vs. DAM
    - Unexpected or non-modeled outages
- New nomograms introduced

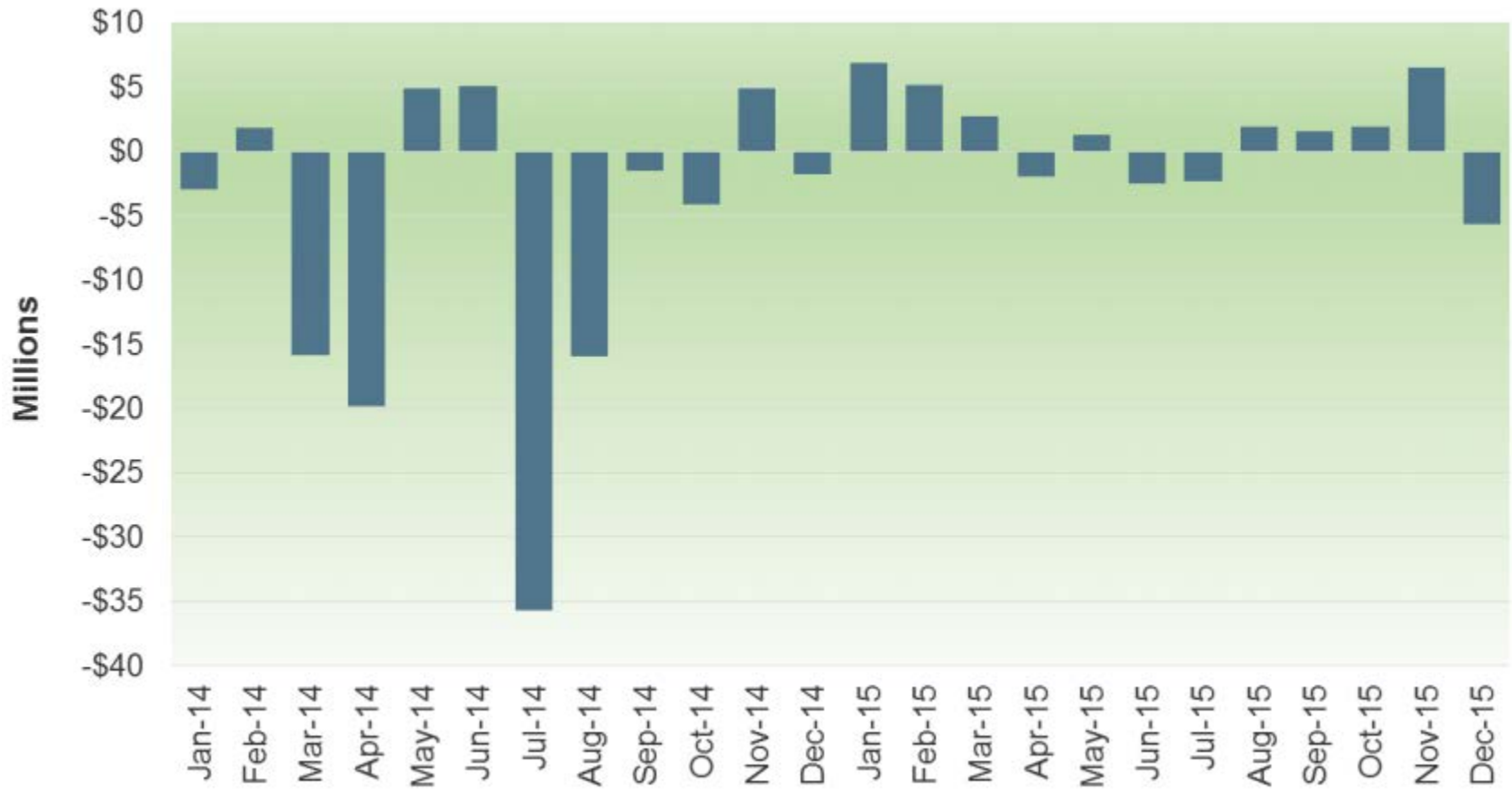All current issues are related to base case and preventive constraints.

Congestion revenue rights market revenue inadequacy without including auction revenues
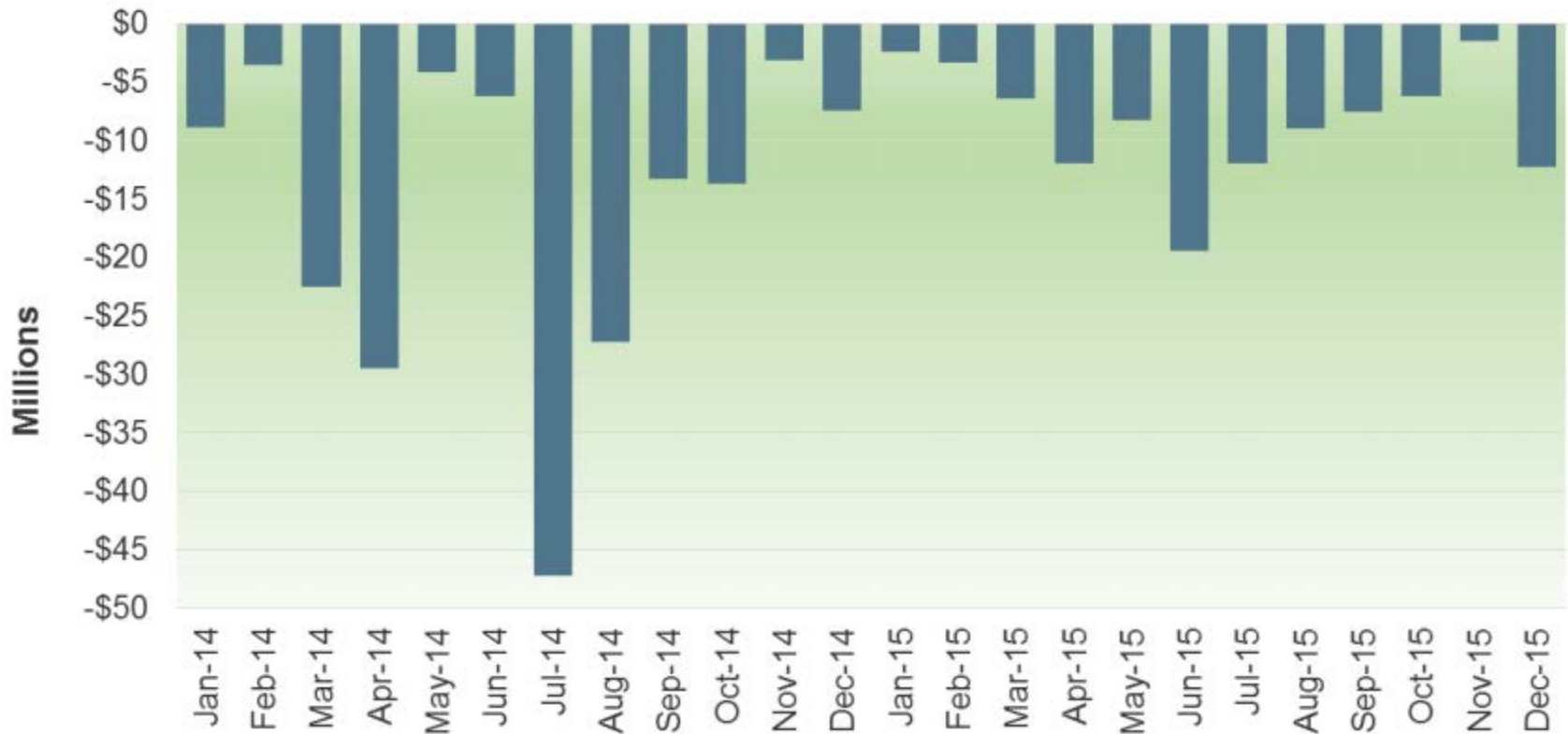
CRR revenue adequacy does not include monthly and annual auction avenues.

■ Revenue Adequacy

Congestion revenue rights market revenue inadequacy including auction revenues

Current CRR Revenue Inadequacy

With CME implementation, we permanently add a new type of constraint (preventive-corrective constraint) to the DAM.

- New complex constraint in DAM

- Evaluates a new case with a different topology and different limits.

- Enforces different limits in post-contingency cases.

- We know these topologies and limits at the time we establish the constraint (prior to CRR market). How to model it in the CRR market?

Contingency modeling enhancements discussion
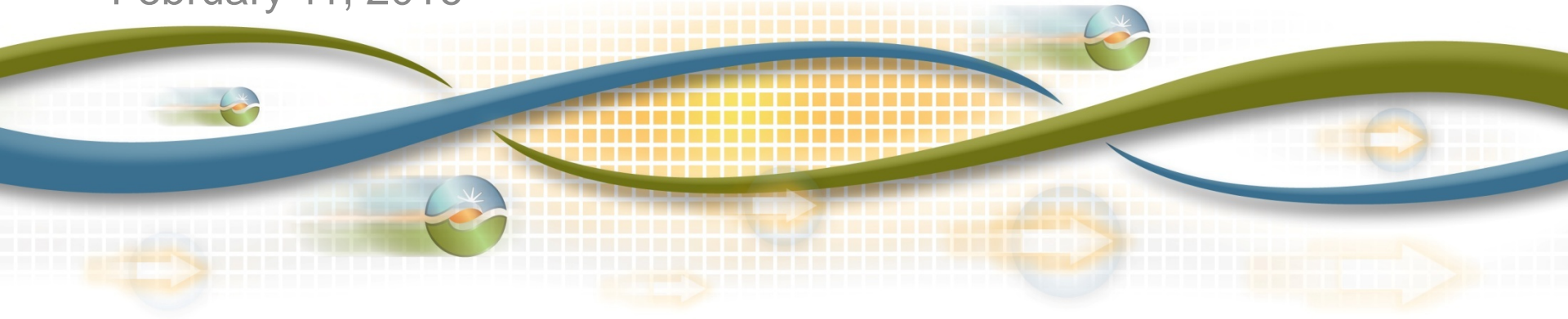
CRR Alternatives Discussion Paper

Perry Servedio

Senior Market Design and Regulatory Policy Developer
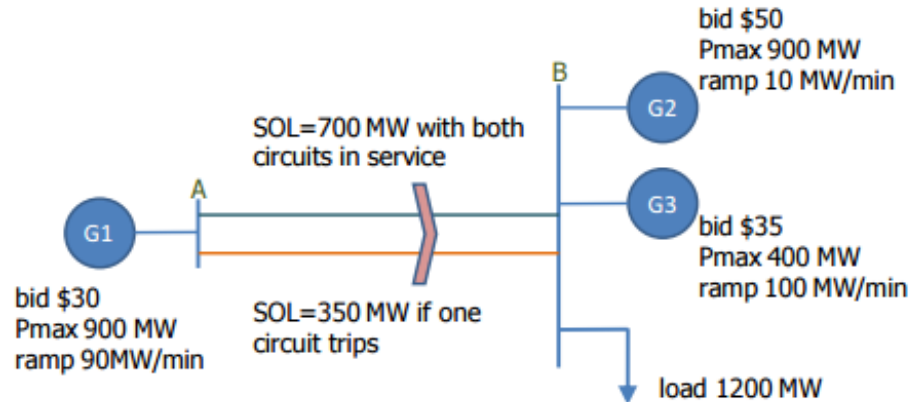
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What is CME?
Preventive-corrective model

SOL=700 MW with both circuits in service

A

B

bid $50
Pmax 900 MW
ramp 10 MW/min
G2

G3
bid $35
Pmax 400 MW
ramp 100 MW/min

G1

bid $30
Pmax 900 MW
ramp 90MW/min

SOL=350 MW if one circuit trips

load 1200 MW

Weak-preventive model energy in base case								
Generator	P^0	λ^0	SF^0_{AB}	μ^0_{AB}	LMP	Bid Cost	Revenue	Profit
G1	700	$50	1	-$5	$30	$21,000	$21,000	$0
G2	250	$50	0	-$5	$50	$12,500	$12,500	$0
G3	250	$50	0	-$5	$50	$8,750	$12,500	$3,750

Corrective capacity in contingency kc=1								
Generator	ΔP^1	λ^1	SF^1_{AB}	μ^1_{AB}	$LMCP^1$	Bid Cost	Revenue	Profit
G1	-350	$15	1	$-15	$0	$0	$0	$0
G2	200	$15	0	$-15	$15	$0	$3,000	$3,000
G3	150	$15	0	$-15	$15	$0	$2,250	$2,250

Congestion Revenue & Corrective Capacity Revenue

Congestion Revenue & Corrective Capacity

LMP's resulting revenue breaks into 3 components.

LMP$_i$ flow related revenue =

$$\sum_{k=0}^{K}\sum_{l=1}^{m}\left[\mu_l^{k*}\cdot F_l^{k,\max}\right]+\sum_{kc=K+1}^{KC}\sum_{l=1}^{m}\left[\mu_l^{kc*}\cdot F_l^{kc,\max}\right]-\sum_{kc=K+1}^{K+KC}\sum_{i}\left[\left(\lambda^{kc*}+\sum_{l=1}^{m}SF_{l,i}^{kc}\cdot\mu_l^{kc*}\right)\cdot\Delta P_i^{kc*}\right]$$

congestion rent collected

corrective capacity revenue collected

California ISO

Congestion Revenue & Corrective Capacity
Congestion Rent from Energy Schedules

$$\sum_i \mu^{k,l} * SF_i^{k,l} * MW_i^{DA} \qquad \sum_i \mu^{kc,l} * SF_i^{kc,l} * MW_i^{DA}$$

MW

$Limit^{k,l}$

$\longleftarrow \sum_i \mu^{kc,l} * \left(Limit^{k,l} - Limit^{kc,l}\right)$

$Limit^{kc,l}$

$\longleftarrow \sum_i \mu^{kc,l} * Limit^{kc,l}$

$\mu^{k,l} = \$5$ $\qquad$ $\mu^{kc,l} = \$15$
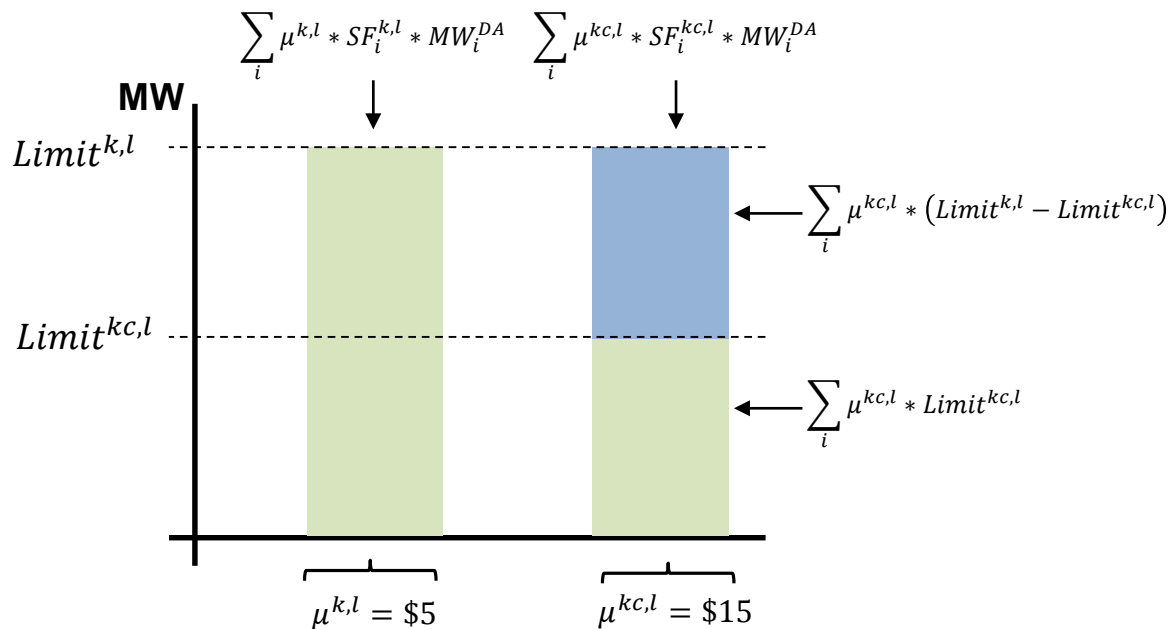
700MW*(\$5/MW) + 350MW*(\$15/MW) + 350MW*(\$15/MW) = \$14,000

\$3,500 $\qquad$ + \$5,250 $\qquad$ + \$5,250 $\qquad\qquad$ = \$14,000

No ED cost

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Congestion Revenue & Corrective Capacity
Example: isolate congestion to kc case

Bid: $30
Pmax: 600 MW
Ramp: 100 MW/m

G1

SOL = 700 MW with all circuits in service

SOL = 350 MW if one circuit trips
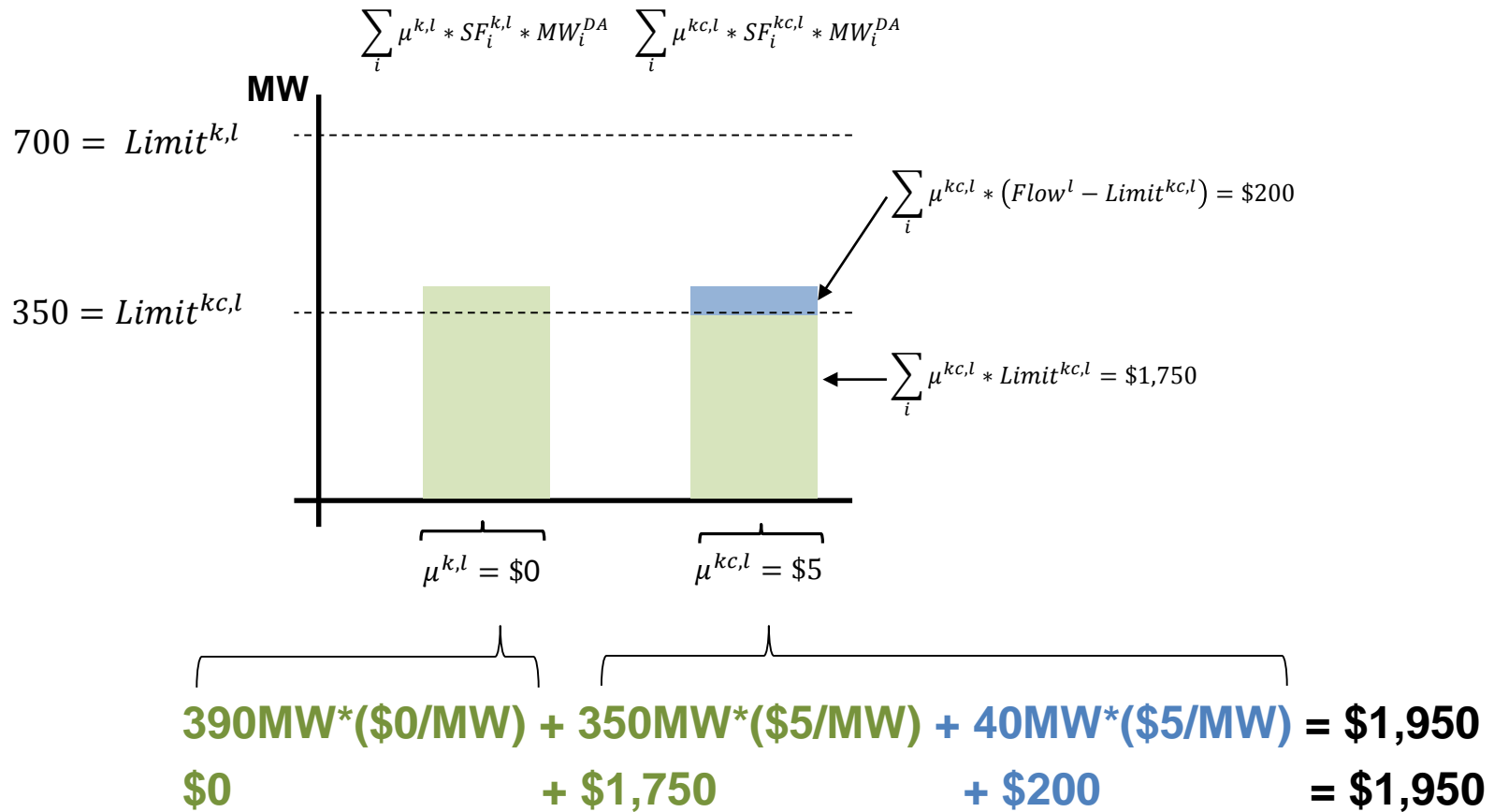
Bid: $50
Pmax: 900 MW
Ramp: 1 MW/m

G2

Bid: $35
Pmax: 900 MW
Ramp: 1 MW/m

G3

Load: 600 MW

Preventive-corrective model energy in base case					
Generator	P^0	λ^0	SF^0_{AB}	μ^0_{AB}	LMP
G1	390	$35	1	$0	$30
G2	0	$35	0	$0	$35
G3	210	$35	0	$0	$35
Corrective capacity in contingency kc=1					
Generator	ΔP^1	λ^1	SF^1_{AB}	μ^1_{AB}	$LMCP^1$
G1	-40	$5	1	-$5	$0
G2	20	$5	0	-$5	$5
G3	20	$5	0	-$5	$5

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Congestion Revenue & Corrective Capacity
Congestion Rent from Energy Schedules

$$\sum_i \mu^{k,l} * SF_i^{k,l} * MW_i^{DA} \qquad \sum_i \mu^{kc,l} * SF_i^{kc,l} * MW_i^{DA}$$

MW

$700 = Limit^{k,l}$

$\sum_i \mu^{kc,l} * \left(Flow^l - Limit^{kc,l}\right) = \$200$

$350 = Limit^{kc,l}$

$\sum_i \mu^{kc,l} * Limit^{kc,l} = \$1{,}750$

$\mu^{k,l} = \$0$ $\qquad$ $\mu^{kc,l} = \$5$

390MW*($0/MW) + 350MW*($5/MW) + 40MW*($5/MW) = $1,950

$0 $\qquad$ + $1,750 $\qquad$ + $200 $\qquad$ = $1,950

CRR Alternatives

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CRR Alternatives
Overview

We organize the options into three paradigms.

Minimal Implementation	**CCRR Paradigm** Allocation Method Auction Method	**CRR^k/CRR^{kc} Paradigm** Allocation Method Auction Method

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CRR Alternatives
Minimal Implementation Paradigm

- ***Option 1(a):*** no change

- ***Option 1(b):*** enforce N-1-1 limits in a strong preventive fashion in the CRR model

CRR Alternatives
Option 1(b) auction simulation

Simulated February 2016 Auction

- Total MW auctioned dropped by 4,474 MW
  - Off-peak
    - Auction decreased from 33,168MW to 30,957MW
    - 16.9% of submitted bids changed from original awards
  - On-peak
    - auction decreased from 45,136MW to 42,873MW
    - 15.4% of submitted bids changed from original awards
- Total auction revenues dropped by $730,107
  - Off-peak: 15.9% paid $96,531 more, 16.3% paid $249,929 less
  - On-peak: 14.8% paid $631,706 more, 15.8% paid $1,208,415 less

CRR Alternatives
CCRR Paradigm

- Settle CRR as today which ends up looking like this with the new preventive-corrective model:

$$CRR\ Payment = CRR\ MW_{AB} \times \left(MCC_B^k - MCC_A^k + MCC_B^{kc} - MCC_A^{kc} \right)$$

- Create new "CCRR" to rescind revenue in excess of available transmission capability.

$$CCRR\ Payment_{BA} = CCRR\ MW_{BA} \times \left(MCC_A^{kc} - MCC_B^{kc} \right)$$

CRR Alternatives
CCRR Paradigm - <u>Allocation</u>

- Weighted Least Squares allocation of CCRR
    - Total end result not much different
    - Consistent with today
    - Distributed allocation
    - Perhaps easier to implement

- Pro-rata allocation of CCRR to CRR holders
   - Involves new post-process

CRR Alternatives
CCRR Paradigm – Auction

- ***Option 2(a)*** Separate bids for simultaneous auction of CRR and CCRR,

- ***Option 2(b)*** Single bid for auction of CRR and CCRR, and

- ***Option 2(c)*** Single bid for auction of CRR and sequential allocation of CCRR pro-rata.

CRR Alternatives
CCRR Paradigm – Auction – Option 2(a)

Bid 700 MW CRR$_{AB}$

Bid 350 MW CCRR$_{BA}$

Auction

700 MW CRR$_{AB}$ award
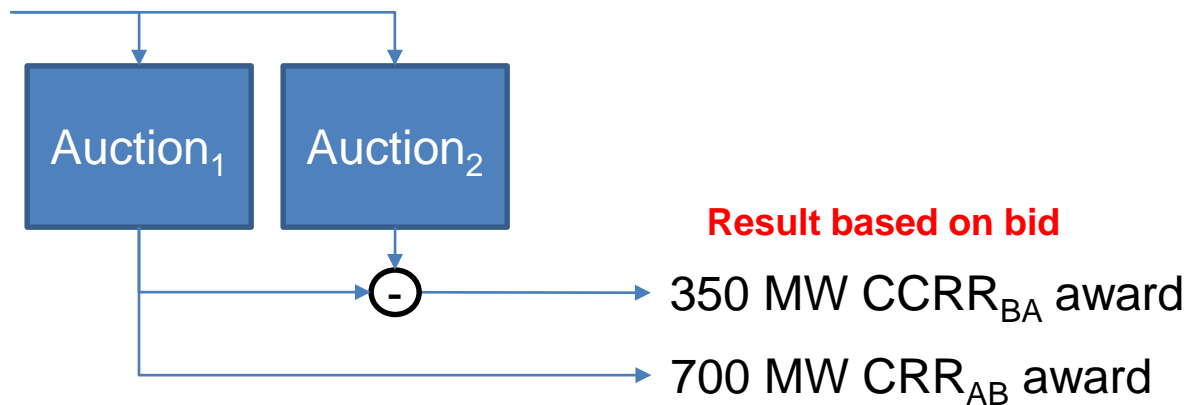
350 MW CCRR$_{BA}$ award
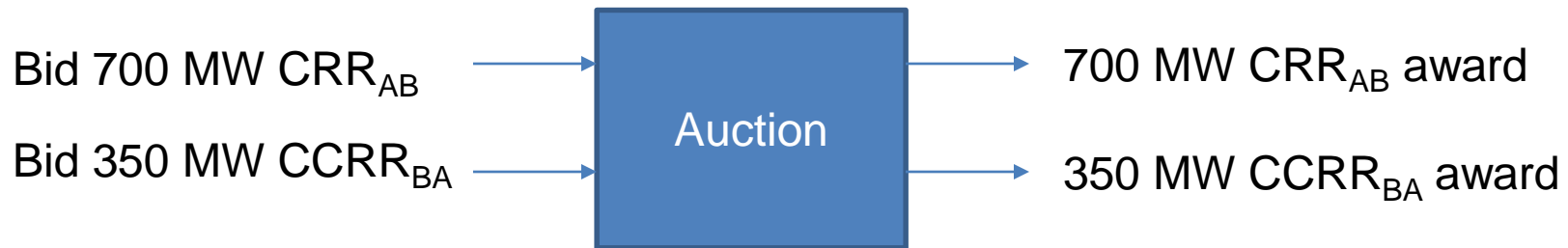
Use separate bids:

- Bid separate for CRR and CCRR
- Auction uses bids to maximize revenue while respecting both k and kc constraints

Participant	CRR Ask (MW)	CRR Bid ($/MW)	CRR Award (MW)	Auction Clearing Price	DAM CRR Settlement
X	600 CRR$_{AB}$ 350 CCRR$_{BA}$	$20 -$15	600 MW CRR$_{AB}$ 350 MW CCRR$_{BA}$	$19 CRR$_{AB}$ -$15 CCRR$_{BA}$	$12,000.00 -$5,250.00
Y	600 CRR$_{AB}$ 350 CCRR$_{BA}$	$19 -$16	100 MW CRR$_{AB}$ 0 MW CCRR$_{BA}$		$2000.00 $0.00

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CRR Alternatives
CCRR Paradigm – Auction – Option 2(b)

Bid 700 MW CRR

$$\text{Auction}_1 \quad \text{Auction}_2$$

Result based on bid

$-$

350 MW CCRR$_{BA}$ award
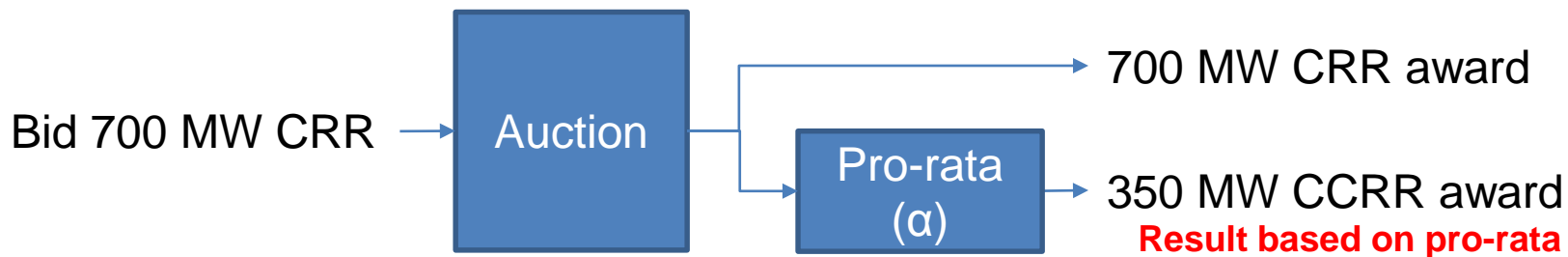
700 MW CRR$_{AB}$ award

Use single bid:

- First auction iteration clears CRRs
- Run second auction with post-contingency topology and kc limit.
- First auction iteration award minus second auction iteration award clears CCRRs

Participant	CRR Ask (MW)	CRR Bid ($/MW)	CRR Award (MW)	Auction Clearing Price	DAM CRR Settlement
X	600	$20	600 MW CRR$_{AB}$ 250 MW CCRR$_{BA}$	$18 CRR$_{AB}$	$12,000.00 -$3,750.00
Y	600	$18	100 MW CRR$_{AB}$ 100 MW CCRR$_{BA}$		$2,000.00 -$1,500.00

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CRR Alternatives
CCRR Paradigm – Auction – Option 2(c)

- Use single bid to clear CRR auction as today
- Allocate CCRR pro-rata

Participant	CRR Ask (MW)	CRR Bid ($/MW)	CRR Award (MW)	Auction Clearing Price	DAM CRR Settlement
X	600	$20	600 MW CRR$_{AB}$ 300 MW CCRR$_{BA}$	$18 CRR$_{AB}$	$12,000.00 -$4,500.00
Y	600	$18	100 MW CRR$_{AB}$ 50 MW CCRR$_{BA}$		$2,000.00 -$750.00

CRR Alternatives
CCRR Paradigm – Auction – Option 2(c)

Pro-rata formulation:

$$MWCCRR_{BA,X} = MWCRR_{AB,X} \times \alpha^{kc}$$

Where,

$$\alpha^{kc} = \max\left\{0, \frac{\sum_p \left(SF_{l,src(p)}^{kc} - SF_{l,snk(p)}^{kc}\right) \cdot CRR_p - F_l^{kc,max}}{\sum_p \left(SF_{l,src(p)}^{kc} - SF_{l,snk(p)}^{kc}\right) \cdot CRR_p}\right\}$$

$$CRR_p = CRRs\ awarded$$

$$p = index\ of\ CRR\ awards$$

$$X = index\ of\ market\ participants$$

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CRR Alternatives
CRR^k/CRR^{kc} Paradigm

- Create a CRR^k product that only settles on the difference in congestion components associated with the k constraint

$$CRR^k\ Payment = CRR^k MW_{AB} \times \left(MCC^k_B - MCC^k_A\right)$$

- Create a CRR^{kc} product that only only settles on the difference in congestion components associated with the kc constraint.

$$CRR^{kc}\ Payment = CRR^{kc} MW_{AB} \times \left(MCC^{kc}_B - MCC^{kc}_A\right)$$

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CRR Alternatives
CRR^k/CRR^{kc} Paradigm – <u>Allocation</u>

- Weighted Least Squares allocation of CRR^{kc}
  - Total end result not much different
  - Distributed allocation
  - Consistent with today
  - Perhaps easier to implement

- Pro-rata allocation of CRR^{kc} to CRR holders
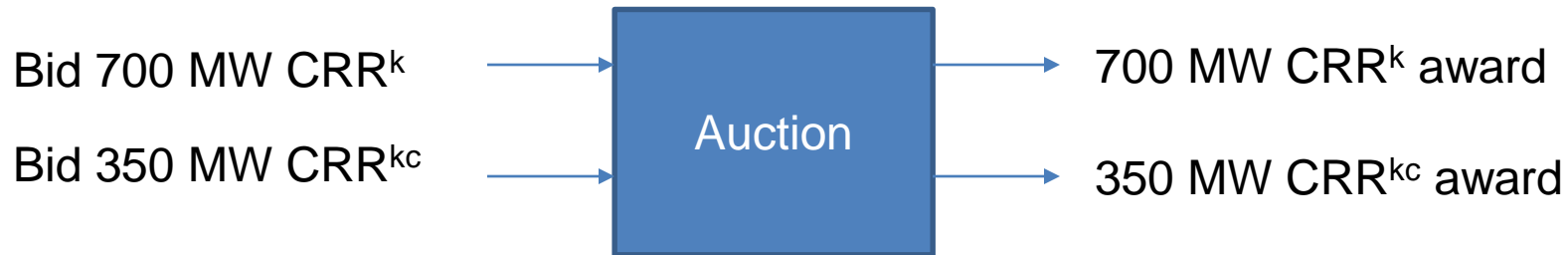 - Involves a new post-process

CRR Alternatives
CRR^k/CRR^{kc} Paradigm – <u>Auction</u>

- ***Option 3(a)*** Separate bids for allocation/auction of CRR^k and CRR^{kc}

- ***Option 3(b)*** Single bid for allocation/auction of CRR^k and CRR^{kc}

- ***Option 3(c)*** Single bid for auction of CRR^k and sequential allocation of CRR^{kc} pro-rata

- ***Option 3(d)*** Single bid for auction of CRR^k only

CRR Alternatives
CRR^k/CRR^{kc} Paradigm – <u>Auction</u> – Option 3(a)

Bid 700 MW CRR^k → **Auction** → 700 MW CRR^k award

Bid 350 MW CRR^{kc} → → 350 MW CRR^{kc} award

Use separate bids:

- Bid separate for CRR^k and CRR^{kc}
- Auction uses bids to maximize revenue while respecting both k and kc constraints

Participant	CRR Ask (MW)	CRR Bid ($/MW)	CRR Award (MW)	Auction Clearing Price	DAM CRR Settlement
X	600 CRR^k	$5	600 MW CRR^k		$3,000.00
	350 CRR^{kc}	$15	0 MW CRR^{kc}	$4 CRR^k	$0.00
Y	600 CRR^k	$4	100 MW CRR^k	$16 CRR^{kc}	$500.00
	350 CRR^{kc}	$16	350 MW CRR^{kc}		$5,250.00

CRR Alternatives
CRR^k/CRR^{kc} Paradigm – <u>Auction</u> – Option 3(b)

Bid 700 MW CRR

CRR^k Auction

CRR^{kc} Auction

350 MW CRR^{kc} award
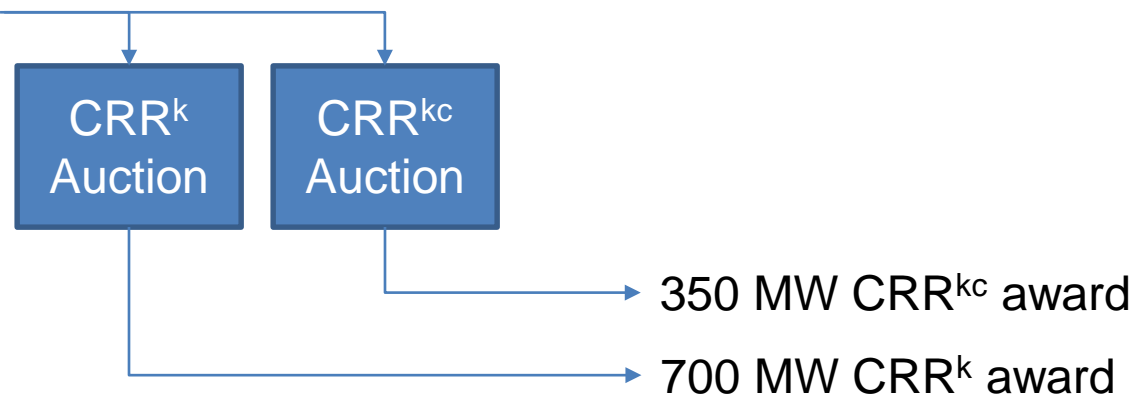
700 MW CRR^k award

Use single bid:

- One auction enforces k limits, clears CRR^k

- Separate auction enforces kc limits with kc topology, clears CRR^{kc}

Participant	CRR Ask (MW)	CRR Bid ($/MW)	CRR Award (MW)	Auction Clearing Price	DAM CRR Settlement
X	600	$20	600 MW CRR^k 350 MW CRR^{kc}	$18 CRR	$3,000.00 $5,250.00
Y	600	$18	100 MW CRR^k 0 MW CRR^{kc}		$500.00 $0.00

CRR Alternatives
CRR^k/CRR^{kc} Paradigm – <u>Auction</u> – Option 3(c)
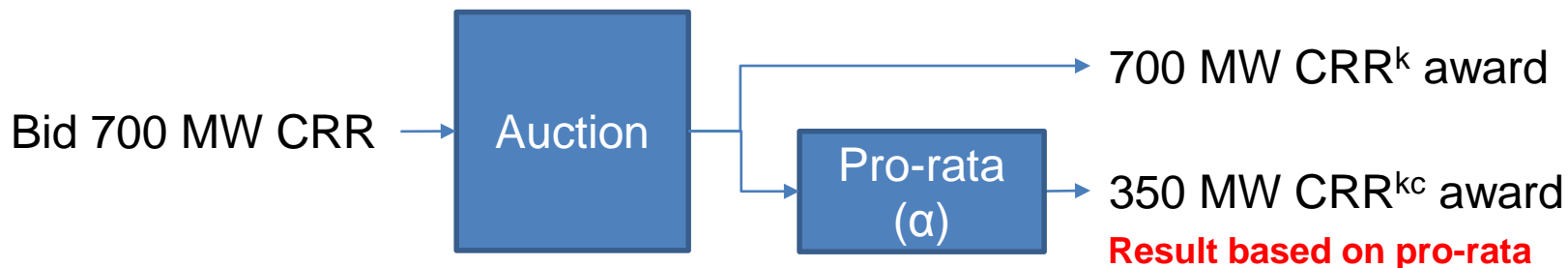
- Use single bid to clear CRR auction as today, this clears the CRR^k
- Allocate CRR^{kc} pro-rata

Participant	CRR Ask (MW)	CRR Bid ($/MW)	CRR Award (MW)	Auction Clearing Price	DAM CRR Settlement
X	600	$20	600 MW CRR^k 300 MW CRR^{kc}	$18 CRR	$3,000.00 $4,500.00
Y	600	$18	100 MW CRR^k 50 MW CRR^{kc}		$500.00 $750.00

CRR Alternatives
CRR^k/CRR^{kc} Paradigm – <u>Auction</u> – Option 3(c)

Pro-rata formulation:

$$MWCRR^{kc}{}_{AB,X} = MWCRR^k_{AB,X} \times \alpha^{kc}$$

Where,

$$\alpha^{kc} = \frac{min\left(F_l^{kc,max}, \sum_p (SF^{kc}_{l,src(p)} - SF^{kc}_{l,snk(p)}) \cdot CRR^k_p\right)}{\sum_p (SF^{kc}_{l,src(p)} - SF^{kc}_{l,snk(p)}) \cdot CRR^k_p}$$

$$CRR^k_p = CRR^k \; awarded$$

$$p = \; index \; of \; CRR \; awards$$

$$X = index \; of \; market \; participants$$

Next Steps

Next Steps

Date	Event
Wed 2/19/16	Stakeholder comments due on CRR Alternatives Discussion Paper
Wed 2/24/16	Prototype Technical Analysis Results posted
Wed 3/8/16	Stakeholder meeting
Wed 3/16/16	Stakeholder comments due on Prototype Technical Analysis Results
Wed 3/23/16	Publish fourth revised straw proposal
Wed 2/19/16	Stakeholder comments due on CRR Alternatives Discussion Paper
Wed 2/24/16	Prototype Technical Analysis Results posted
Wed 3/8/16	Stakeholder meeting

Please submit comments to initiativecomments@caiso.com

Questions