

# Flexible Ramping Products and Cost Allocation

Revised Straw Proposal, December 5, 2011

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and

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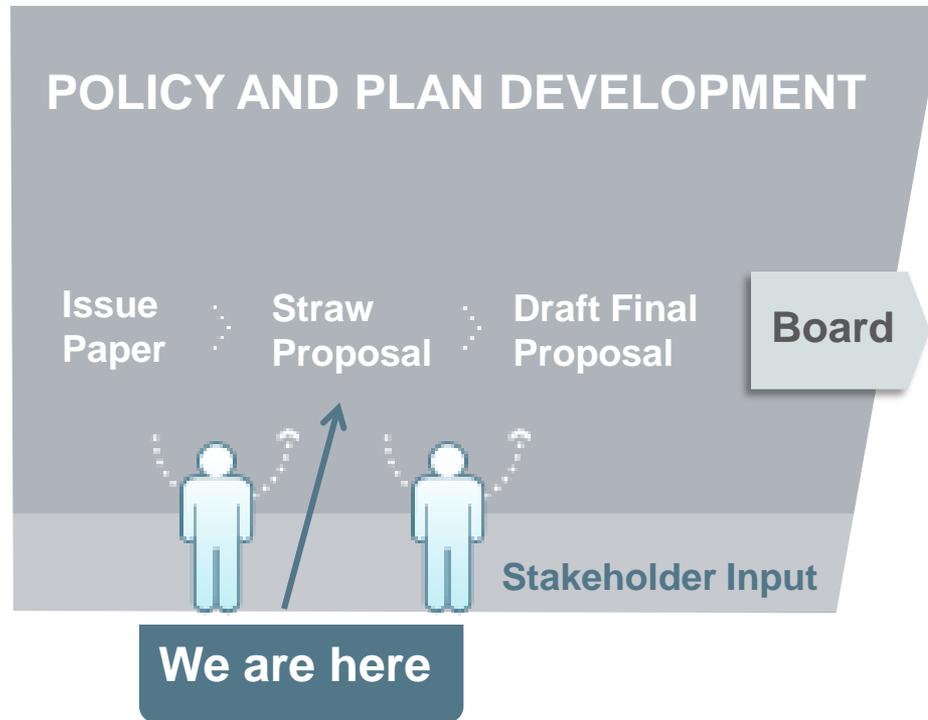
Senior Market Design and Policy Specialist



# Agenda

Time	Topic	Presenter
10:00 – 10:15	Introduction	Chris Kirsten
10:15 – 12:00	Product Design and Examples	Lin Xu
12:00 – 1:00	Lunch Break	All
1:00 – 3:00	Product Design and Examples cont.	Lin Xu
3:00 – 3:15	Break	All
3:15 – 3:45	Cost Allocation	Don Tretheway
3:45 – 4:00	Next Steps	Chris Kirsten

# ISO Policy Initiative Stakeholder Process



# What is new in the revised straw proposal?

- Clarifications in response to stakeholders
- Flexible ramping product day-ahead and real-time procurement targets
- Interplay of day-ahead market and RTPD in terms of conversions between non-contingent spinning reserve and upward flexible ramping products in RTPD
- Third RTD interval deployment method
- More intuitive examples
- Cost allocation method

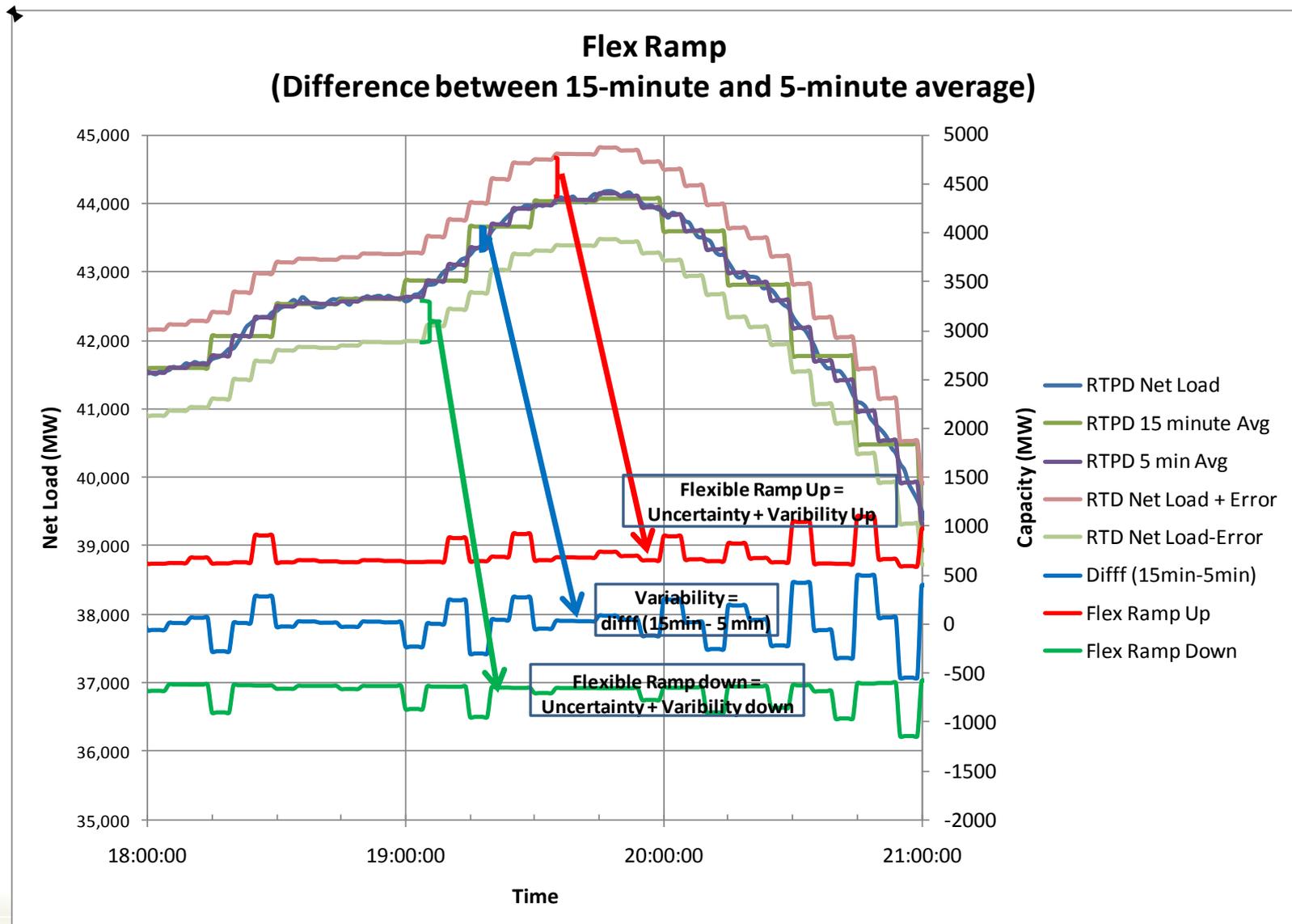
# What is the purpose of the flexible ramping products?

- Handle imbalance difference between RTPD and RTD
  - Variability: difference due to modeling granularity difference (15 minute vs. 5 minute)
    - Load forecast profile
    - Variable energy resource profile
    - Unit startup and shutdown profile
    - Inter-tie inter-hour schedule profile
  - Uncertainty: random events happened between RTPD and RTD
    - Load forecast error
    - Variable energy resource forecast error
    - Forced outage
    - Uninstructed deviation

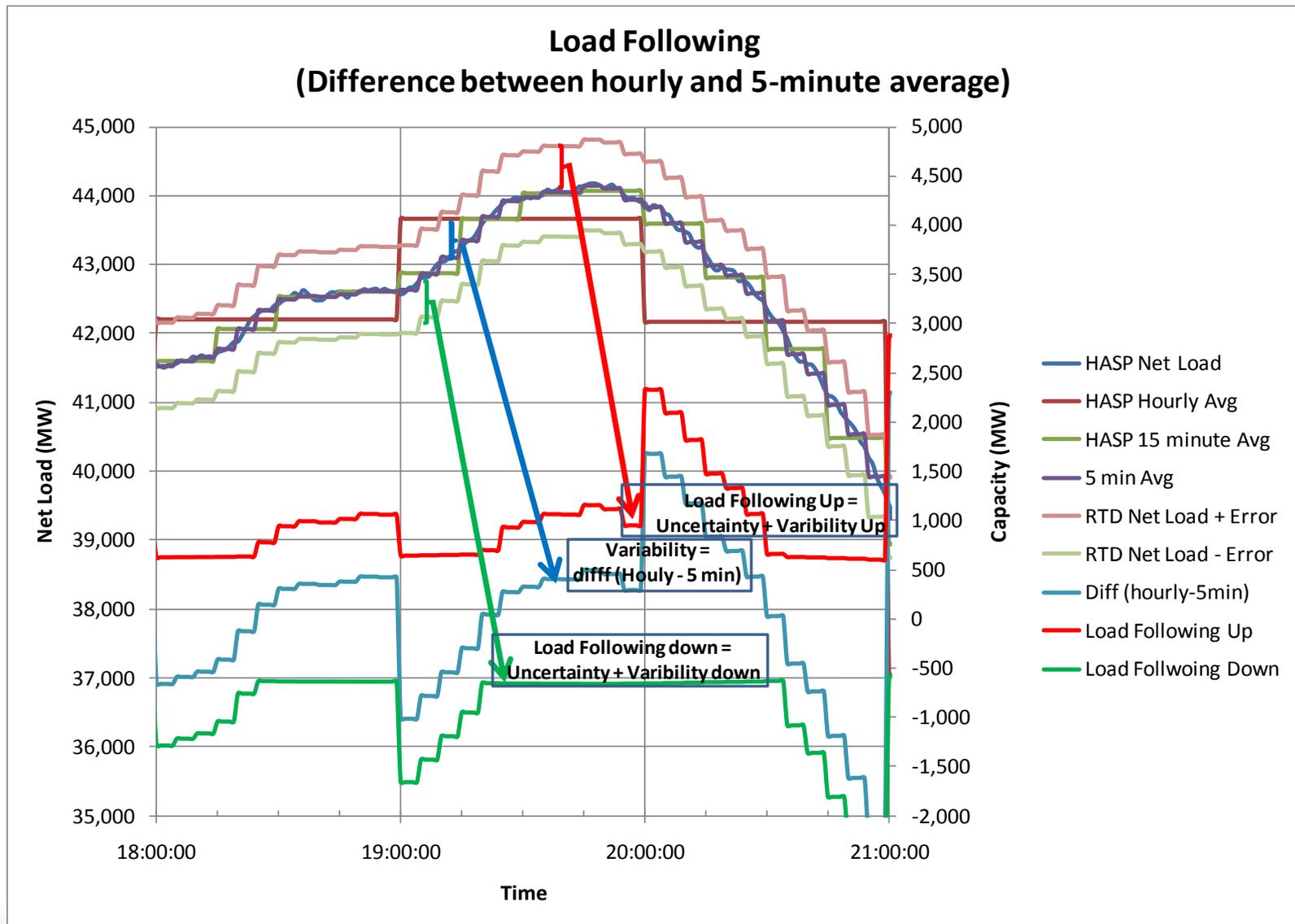
# Flexible ramping products design

- Upward product and downward product
- Awards based on how much a resource can ramp in 5 minutes
  - Aligned with RTD market clearing interval
  - Procurement can be fully deployed in one RTD interval if it is needed
- Allow economic bids
  - Bid to express willingness of providing flexible ramping
  - Must have economic energy bids to back up the flexible ramping products bids
- Procured in day-ahead and RTPD
  - Co-optimized with energy and ancillary services
  - Requirement based on anticipated RTPD and RTD deviations
    - Being able to cover the derivations with high confidence level
    - Allow requirement relaxation at appropriate penalty price
- Deployed in RTD
  - Converted to energy schedules only when it is necessary

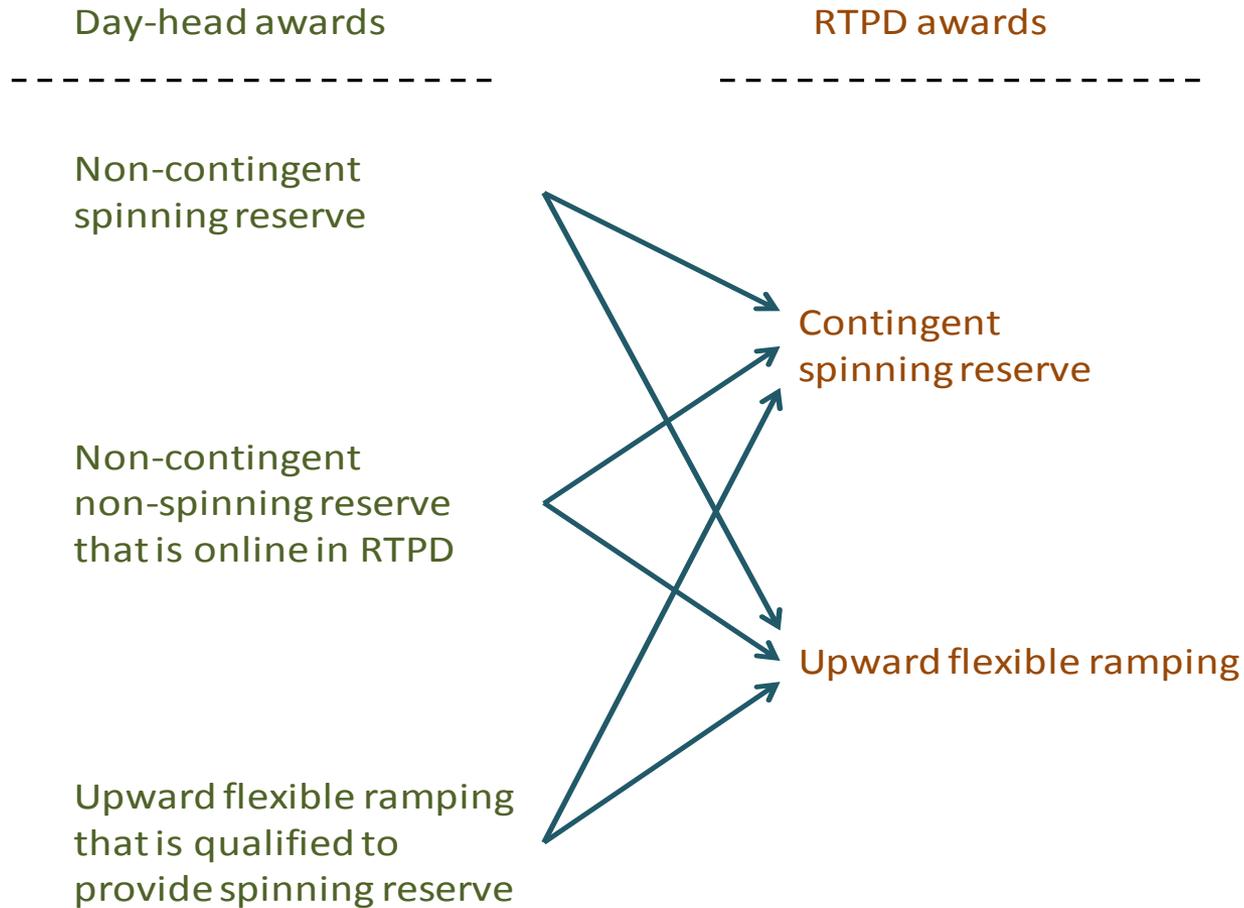
# Calculate the flexible ramping requirement



# Relationship to load following



# Day-ahead to RTPD conversions



# Conversion characteristics

- Direction
  - Not predetermined
  - From lower value product to higher value product
  - Can only happen in one direction in one ancillary service region
- Amount
  - Partial or full
  - Flexible ramping limited by 5-minute ramping capability
- Settlement
  - Product A in day-ahead to product B in RTPD conversion
  - Day-ahead price: day-ahead product A price
  - Real-time price: RTPD product B price minus RTPD product A price

# A three-generator example

gen	bid							initial condition						
	energy	reg up	reg down	spin	non spin	flex ramp up	flex ramp down	energy	reg up	reg down	spin	non spin	flex ramp up	flex ramp down
G1	30	2.5	2	0	0	3	3	190	0	10	5	0	0	8
G2	35	2.8	2.2	0	0	2	2	90	0	0	5	0	0	0
G3	50	1.5	1	0	0	1	1	10	10	0	10	0	20	0

gen	Pmin	Pmax	operational ramp rate	regulation ramp rate
G1	10	200	3	3
G2	10	300	1	1
G3	10	50	5	5

## Ramp sharing (with energy)

- Not sharing from regulation and flexible ramping products
- Allow sharing from spinning and non-spinning reserves

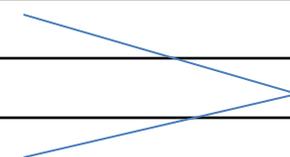
## Requirements

- Load 300 MW
- Reg-up 10 MW
- Reg-down 10 MW
- Spinning 25 MW
- Non-spinning 0 MW
- Upward flexible ramping 20 MW
- Downward flexible ramping 8 MW

# RTPD solution

gen	Energy schedule	Reg Up schedule	Reg down schedule	Spin schedule	Non-spin schedule	Flex ramp up schedule	Flex ramp down schedule
G1	195	0	10	5	0	0	3
G2	95	0	0	5	0	5	5
G3	10	10	0	15	0	15	0

Product	Price (\$/MWh)
Energy	35
Regulation-up	6.5
Regulation-down	2
Spinning reserve	5
Non-spinning reserve	0
Upward flexible ramping product	6
Downward flexible ramping product	3



It is economic to convert spinning reserve to upward flexible ramping

# Day-ahead award conversions in RTPD

- Adding G4 with 6 MW day-ahead non-contingent spinning reserve award
  - Ramp rate 1 MW/minute

gen	Energy schedule	Reg Up schedule	Reg down schedule	Spin schedule	Non-spin schedule	Flex ramp up schedule	Flex ramp down schedule
G1	200	0	10	0	0	0	3
G2	90	0	0	5	0	5	5
G3	10	10	0	19	0	10	0
G4	0	0	0	1	0	5	0

Product	Price (\$/MWh)
Energy	35
Regulation-up	1.5
Regulation-down	2
Spinning reserve	0
Non-spinning reserve	0
Upward flexible ramping product	1
Downward flexible ramping product	3

# RTD deployment terminologies

- Dispatched
  - Dispatched for energy
  - Not depend on if a resource carries flexible ramping awards or not
  - Resource specific
- Released
  - Made available for dispatch
  - System wide, not resource specific
  - Released amount equal to total realized imbalance difference
- Deployed
  - Released and dispatched into flexible ramping awards
  - Remaining flexible ramping capability must be less than original award after deployment
  - Resource specific
  - It is possible that a resource carries flexible ramping awards is dispatched for energy only without deploying its flexible ramping awards

# RTD deployment method

- Release
  - amount equal to realized imbalance difference in RTD1 and RTD2, no release limitation in RTD3 (as long as it can fulfill its flexible ramping awards for next RTPD)
  - One direction: upward for upward and downward for downward
- Dispatch
  - RTD economic dispatch constrained by the release limitation
  - Only consider energy bids, not consider flexible ramping bids
- Deploy
  - Outcome of dispatch
  - In economic order
  - If a resource's capacity is not limiting, a resource will be dispatched without deploying its flexible ramping, i.e. its economic energy being dispatched and its flexible ramping capability kept in the current RTD to be used in the next RTD

# RTD deployment example

gen	Energy bid	Pmin	Pmax	Initial MW	Ramp rate	RTPD upward flex ramp award	RTPD downward flex ramp award
G1	35	40	100	50	2	0	10
G2	45	40	100	40	8	40	0
G3	55	20	100	50	10	50	30

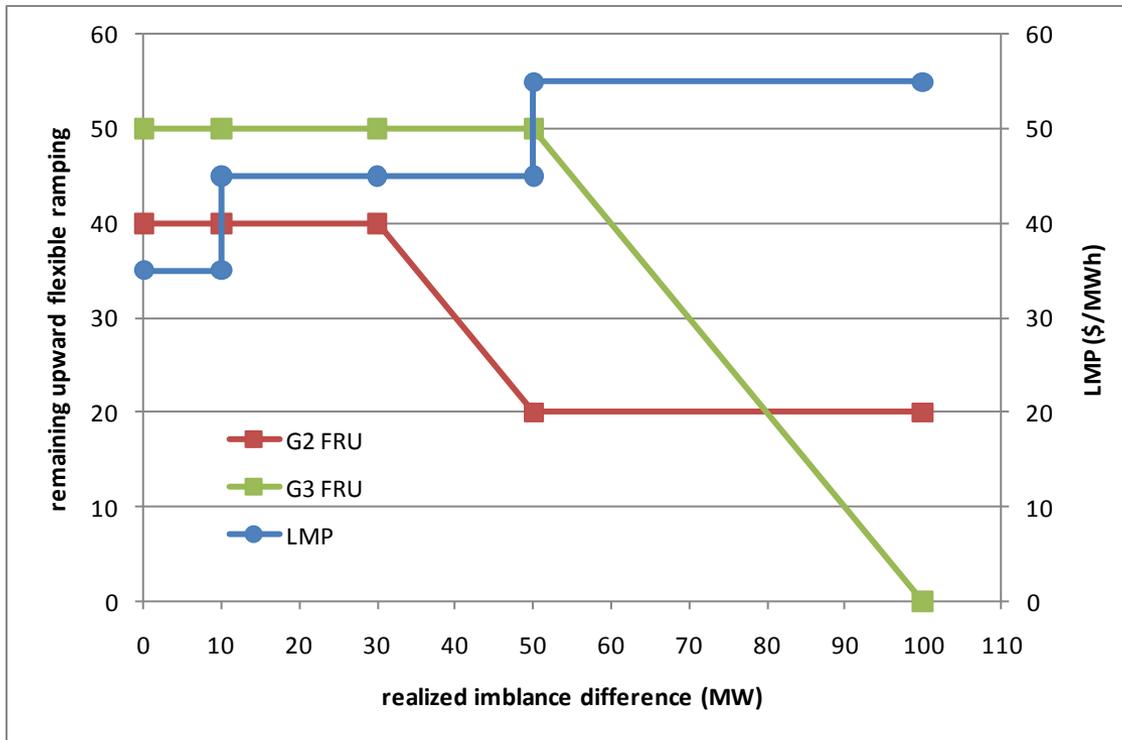
## Dispatch order

- Upward: G1 -> G2 -> G3
- Downward: G3 -> G2 -> G1

## Ramping capability in 5 minutes

- G1 = 10 MW, G2 = 40 MW, G3 = 50 MW

# RTD deployment example – upward direction

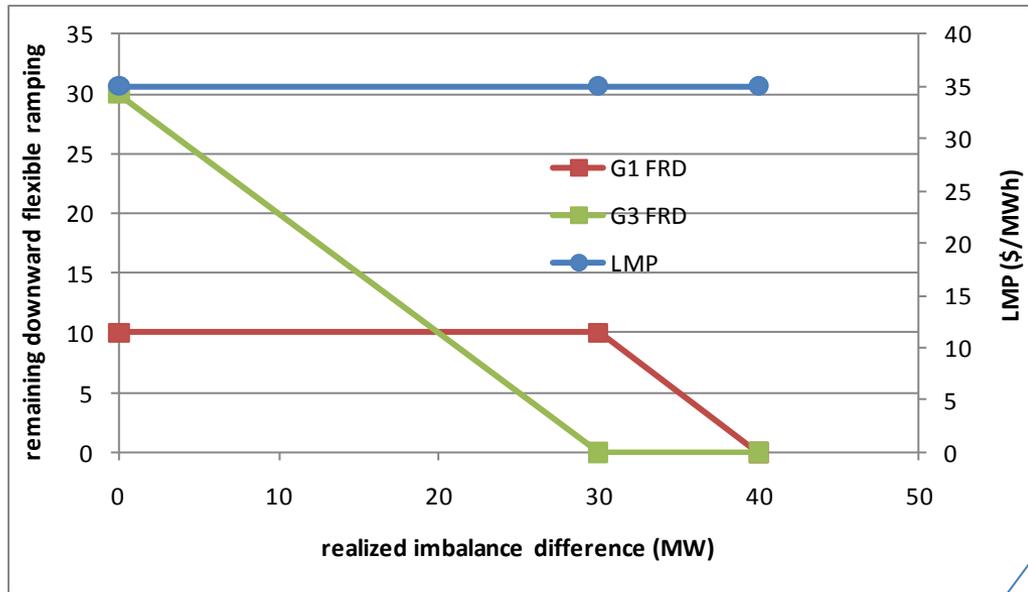


0 MW to 10 MW

- Dispatch G1
- 10 MW to 30 MW
- G1 ramping exhausted
  - Dispatch G2 without deploying flex ramp
- 30 MW to 50 MW
- Deploy G2
- 50 MW to 100 MW
- Deploy G3
- More than 100 MW
- Power balance violation

gen	Energy bid	Pmin	Pmax	Initial MW	Ramp rate	RTPD upward flex ramp award	RTPD downward flex ramp award
G1	35	40	100	50	2	0	10
G2	45	40	100	40	8	40	0
G3	55	20	100	50	10	50	30

# RTD deployment example – downward direction



0 MW to 30 MW

- Deploy G3
- LMP set by G1
- Release limitation prevent over using flex ramp for economic reason

30 MW to 40 MW

- G3 ramping exhausted
- Deploy G1
- LMP set by G1

More than 40 MW

- Power balance violation

- It is more economic to dec G3 by 2 MW and inc G1 by 1 MW to meet 1 MW of realized downward imbalance difference (cost saving  $55 \times 2 - 35 = 75$ )
- This is prevented by the release limitation because it can use up the flex ramp capability more quickly (2 MW used for 1 MW of imbalance difference), and potentially cause ramping shortage later

# RTD deployment example – temporal interplay

## RTD1

80 MW of realized upward imbalance difference

gen	energy	remaining flex ramp up	remaining flex ramp down
G1	60	0	10
G2	80	20	0
G3	80	20	30

- G1 provides 10 MW ramping
- G2 provides 40 MW ramping
- G3 provides 30 MW ramping
- RTD1 LMP is \$55 set by G3's bid

## RTD2

30 MW of realized upward imbalance difference

gen	energy	remaining flex ramp up	remaining flex ramp down
G1	70	0	10
G2	50	40	0
G3	50	50	30

- G3 dispatched down by 30 MW
- G1 dispatched up by 10 MW
- G2 dispatched down by 30 MW
- RTD2 LMP is \$45 set by G2's bid
- Release limitation help restore flexible ramping capability

## RTD3

120 MW of realized upward imbalance difference

gen	energy	remaining flex ramp up	remaining flex ramp down
G1	80	0	10
G2	90	10	0
G3	90	10	30

- G1 provides 10 MW ramping
- G2 provides 40 MW ramping
- G3 provides 40 MW ramping
- RTD3 LMP is \$55 set by G3's bid

# Compensation

- Day-ahead
  - Day-ahead award at day-ahead price
- RTPD
  - Incremental flexible ramping award at RTPD price
  - Upward flexible ramping converted from day-ahead non-contingent spinning reserve at RTPD upward flexible ramping price minus RTPD spinning reserve price
  - Spinning reserve converted from day-ahead upward flexible ramping at RTPD spinning reserve price minus RTPD upward flexible ramping price
- RTD
  - Deployed amount at RTD energy price

# Other discussions

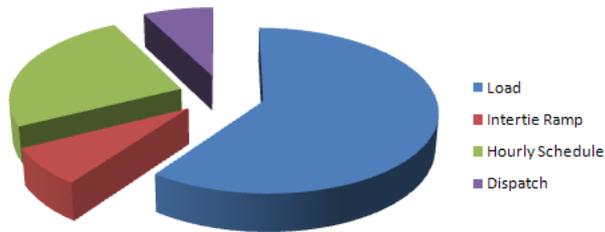
- No-pay rules
  - Undispatchable in RTD
  - Not following RTD instruction
  - Fail to maintain the ramping capability
- Bid cost recovery
  - Flexible ramping product revenue will be included in bid cost recovery calculation
- Lock in day-ahead energy bid supporting flexible ramping
  - Prevent re-bidding higher energy price in real-time

# Cost allocation changes from Straw Proposal

- Flexible ramping product costs will be allocated the same way as Regulation Up/Down AS Obligation
- Inter-SC functionality to trade flexible ramping obligation
- ISO will track resource level deviations and publish aggregated data for each cost bucket
- Added new bucket for Imports and Exports due to hourly ramp of static schedules

# Deviation measurement differs by pie slice

## Flexi-Ramp Up



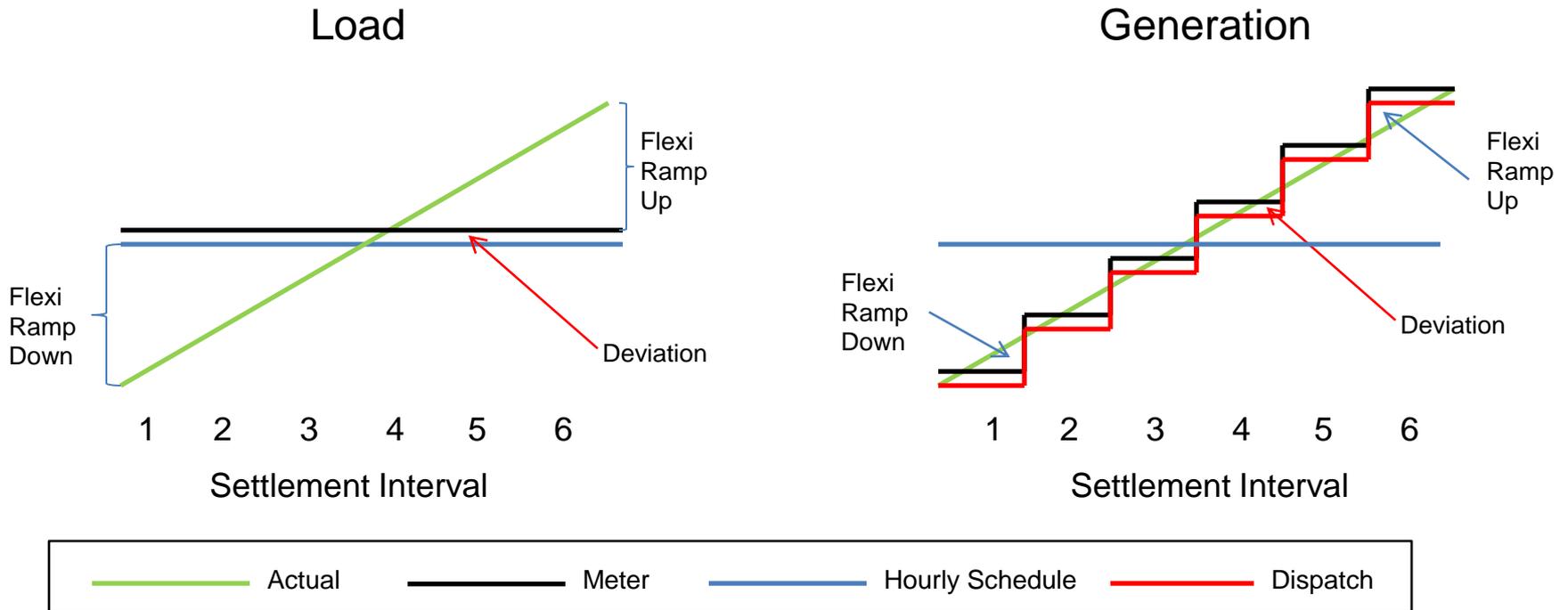
## Flexi-Ramp Down



Bucket	Deviation Metric
UP – Load	Regulation Up AS Obligation
UP - Intertie Ramp	Absolute Value Net Hourly Schedule Change (Import - Export, Wheels Exempt)
UP – Hourly Schedule	Negative Uninstructed Imbalance Energy 2 Negative Operational Adjustments
UP – Dispatch	Negative Uninstructed Imbalance Energy 1
DOWN – Load	Regulation Down AS Obligation
DOWN – Intertie Ramp	Absolute Value Net Hourly Schedule Change (Import - Export, Wheels Exempt)
DOWN – Hourly Schedule	Positive Uninstructed Imbalance Energy 2 Positive Operational Adjustments
DOWN – Dispatch	Positive Uninstructed Imbalance Energy 1

## Deviation data for reporting purposes

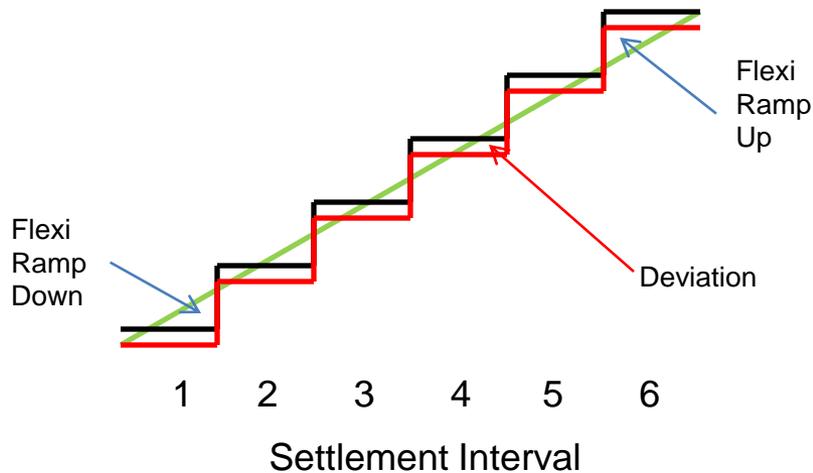
# Meter granularity affects proper measurement of deviations for each cost bucket



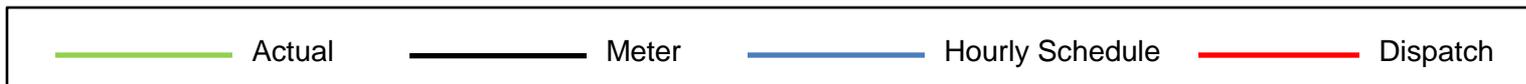
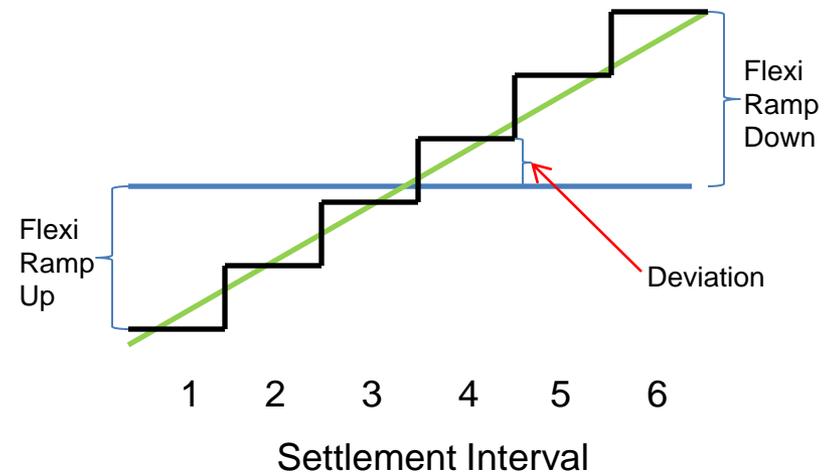
Load and Generation have equivalent measured deviations, but Load is a larger driver of flexi-ramp procurement.

# RT self-schedules by Generation affects proper calculation of deviations

## Generation – Economic Dispatch

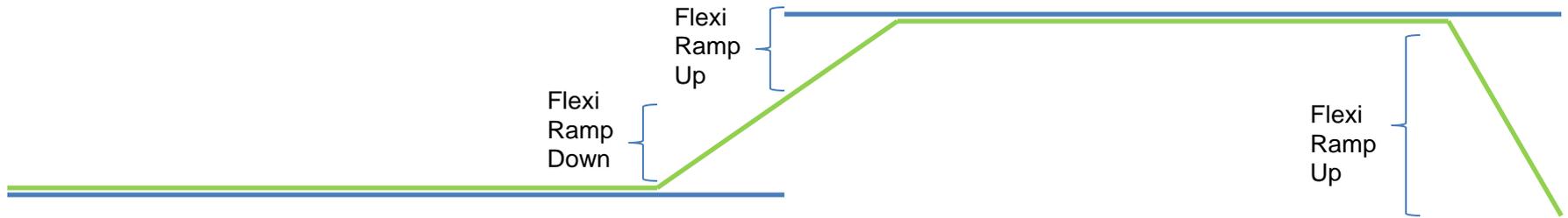


## Generation – RT Self Schedule



Real-time self schedules and economic dispatch require different reference point to measure deviations

# 20 Minute Ramping for Intertie Static Hourly Schedule Changes



1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
RTPD 1			RTPD 2			RTPD 3			RTPD 4			RTPD 1			RTPD 2			RTPD 3			RTPD 4		
Hour Ending 10										Hour Ending 11													

Import Schedule: HE 09 = 100MW, HE 10 = 100MW, HE 11 = 150MW, HE 12 = 50MW



- Flexible Ramping Impact

- 50% of Schedule Change Flexible Ramping Down HE 10, RTPD #4
- 50% of Schedule Change Flexible Ramping Up HE 11, RTPD #1
- 50% of Schedule Change Flexible Ramping Up HE 11, RTPD #4

# Expand Inter-SC trade functionality to allow monthly trades of flexible ramping product obligation

- Actual supply deviations occur after procurement decision
- Procurement target isn't calculated by sum of individual resources, but actual deviation over time can be a proxy of relative impact
- Actual deviation in a single settlement interval may not be indicative of average flexi-ramp cost when the resource did not deviate
- Monthly timeframe allows approximation of average cost
- Flexible Ramping Obligation can be traded either daily or monthly

# Next Steps

Item	Date
Post Straw Proposal	11/1/11
Stakeholder Meeting	11/7/11
Stakeholder Comment	11/14/11
Post Revised Straw Proposal	11/28/11
Stakeholder Meeting	12/5/11
Stakeholder Comment	12/13/11
Post Draft Final Proposal	01/05/12
Stakeholder Meeting	01/12/12
Stakeholder Comment	01/19/12
Board of Governors	02/16/11

- Submit comments to [FRP@caiso.com](mailto:FRP@caiso.com)

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