California ISO
Shaping a Renewed Future

Flexible Ramping Products and Cost Allocation

Straw Proposal, November 7, 2011

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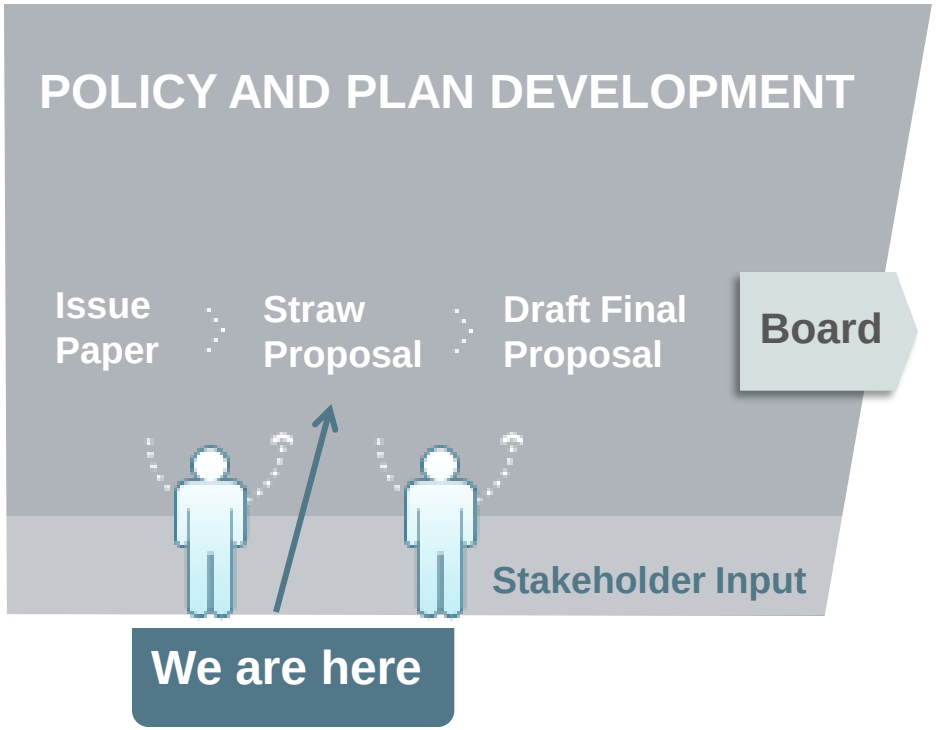
Agenda

Time	Topic	Presenter
10:00 – 10:15	Introduction	Chris Kirsten
10:15 – 12:00	Conceptual Design	Lin Xu
12:00 – 1:00	Lunch Break	All
1:00 – 2:30	Examples	Lin Xu
2:30 – 2:45	Break	All
2:45 – 3:45	Cost Allocation	Don Tretheway
3:45 – 4:00	Next Steps	Chris Kirsten

ISO Policy Initiative Stakeholder Process



Flexible ramping products

- Background
- Understand the flexible ramping products in the context of the market operations temporal hierarchy
- Flexible ramping product design
- Procure flexible ramping products by co-optimization
- Deploy flexible ramping products in RTD
- Compensation
- Example

Background

- Ramping shortage observed in real-time market sometimes

- Increasing balancing challenges from:
  - Increasing penetration of variable energy resources
  - Increasing load uncertainty with distributed energy resources
  - Decreasing fleet flexibility due to environmental restrictions

- Operational needs to be addressed by market mechanism
  - Achieve high economic efficiency
  - Provide the correct incentive

Proposed solutions

	Flexible ramping constraint	Flexible ramping products
solution quality	Interim (2012)	permanent (2013 forward)
product type	upward	upward and downward
product standard	15-minute ramp RTPD 5- minute ramp RTD	5-minute ramp
what problem to address	general ramping capability shortage	uncertainties between RTPD and RTD
product bids	no	yes
procurement time	RTPD	day-ahead and RTPD
RTD deployment penalty price	yes	no
economic RTD energy price	no	yes
restore ramping capability when there is no ramping need	no	yes
cost causation settlement	no	yes

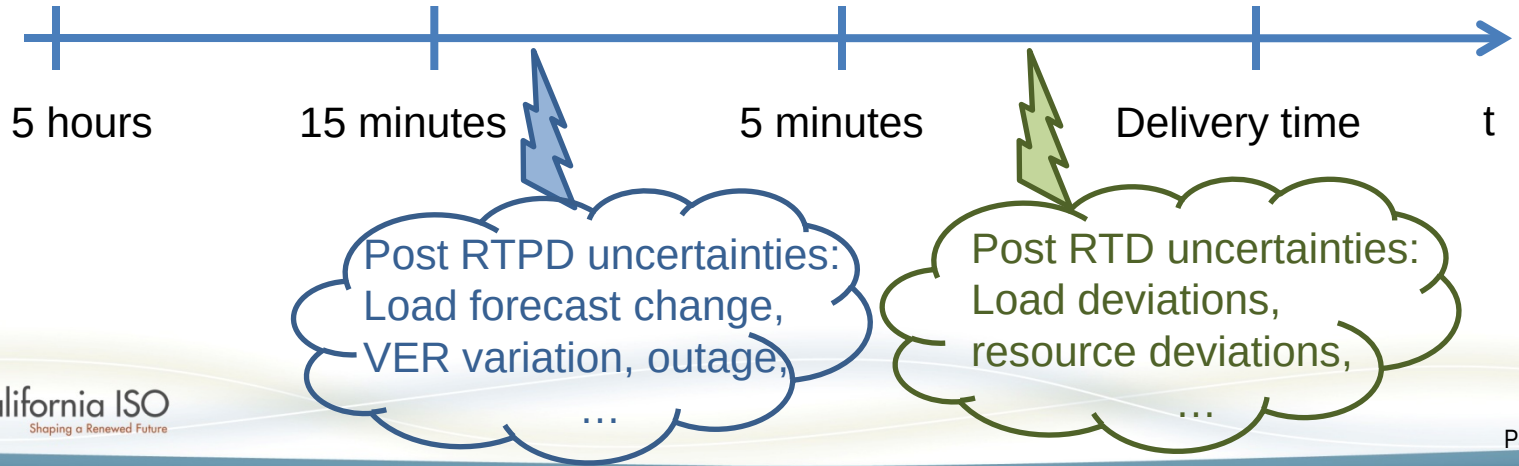
RTPD
unit commitments and ancillary services procurements

RTCD (after serious system disturbance)
operating reserve deployment
unit commitments and economic dispatches

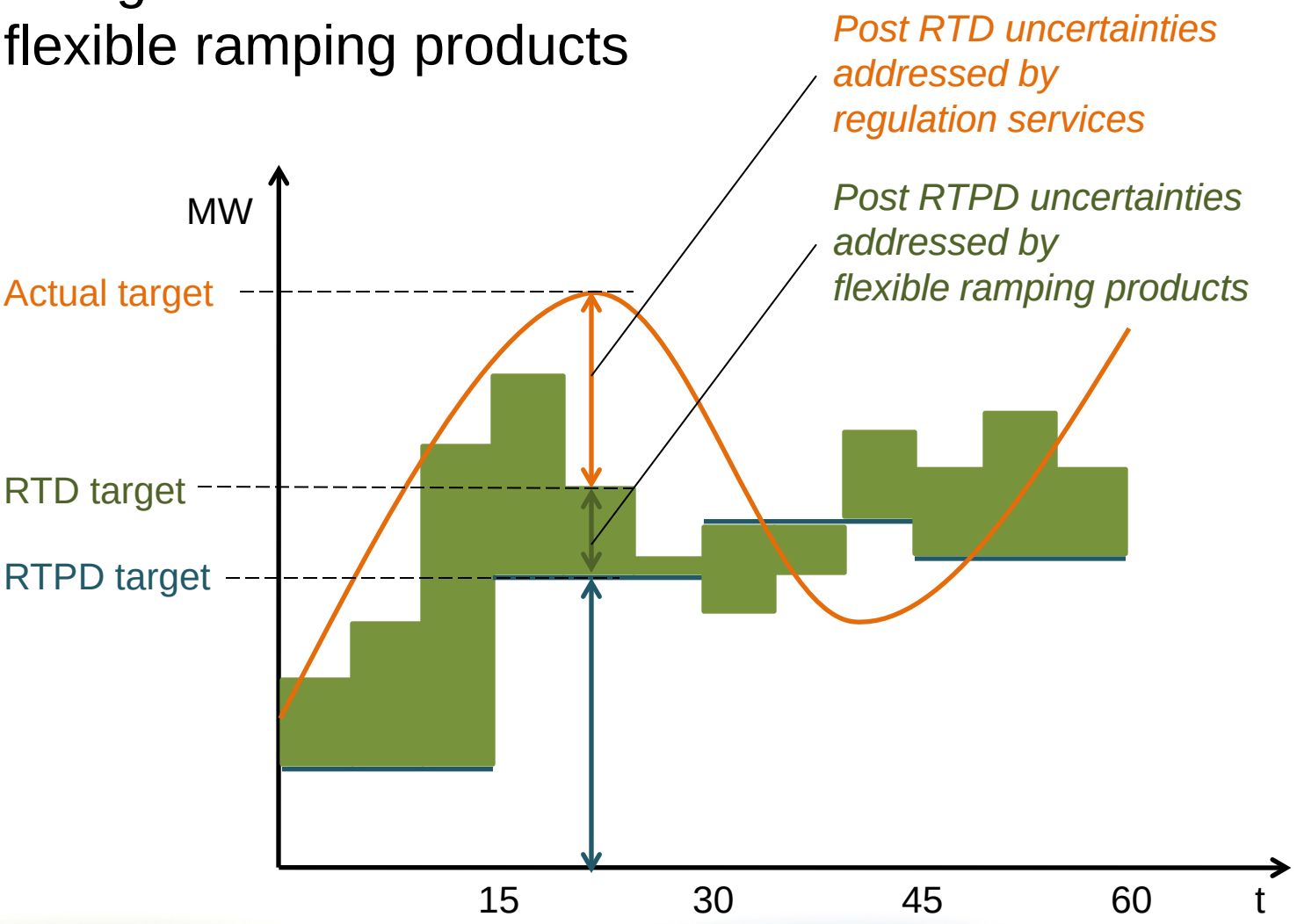
Temporal hierarchy to maintain system balance

RTD
economic dispatches

Automatic Generation Control
Regulation services deployments



The goal of flexible ramping products



Flexible ramping products design

- Upward product and downward product
- Based on what 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 probability
    - Allow requirement relaxation at appropriate penalty price
- Deployed in RTD
  - Converted to energy schedules only when it is necessary

Procure flexible ramping products by co-optimization

- Co-optimize with energy and ancillary services
- No substitution between flexible ramping products and
  - Regulation services
  - Contingent reserves
- No ramp sharing between flexible ramping products and inter-interval energy schedule
- Marginal prices will reflect the opportunity costs of
  - Providing ancillary services
  - Providing the RTPD energy

Deploy flexible ramping products in RTD

- Deploy flexible ramping products only when it is necessary
  - Deploy to address deviations between RTPD and RTD
  - Not to deploy because it is cheap energy
- Deploy the right amount
  - To the extent of meeting the realized deviations between RTPD and RTD
  - Prevent over deployment such that the ramping capability is available for future use
- Restore previously used ramping capability when the realized uncertainty drops
- RTD energy price determined by true economic bids

Compensation

- Capability payment from RTPD
  - Based on marginal prices
  - The ISO is revenue adequate
    - If there is no flexible ramping product scarcity, the ISO is revenue neutral
  - The ISO will be revenue neutral after cost allocation
- Energy payment from RTD for deployed portion
- Is this a double payment because the RTPD marginal prices have included the opportunity cost of providing energy?
  - No!
  - The RTPD marginal prices include opportunity cost of meeting the RTPD energy target, not the RTD target
  - The procured flexible ramping products are only allowed to be deployed for meeting the RTD deviations from RTPD, which are not captured in the RTPD opportunity cost

Flexible ramping product design to be continued

- There are some design details that are not covered in this straw proposal
  - Non-contingent reserves interplay
  - Day-ahead procurement
  - No-pay rules
  - Regional level constraint as future enhancement
- More details about these will be discussed in the next version of the proposal

A three-generator example

	bid							initial condition						
gen	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	2	0	0	0	0	195	0	10	5	0	0	8
G2	35	2	2	0	0	0	0	85	0	0	10	0	0	0
G3	50	1	1	0	0	0	0	10	10	0	5	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
  - 15 MW from load
  - 5 MW from V.E.R.
- Downward flexible ramping 8 MW
  - 5 MW from load
  - 3 MW from V.E.R.

RTPD Solution

gen	Energy schedule	Reg up schedule	Reg down schedule	Spin schedule	Non Spin schedule	Flex up schedule	Flex down schedule
G1	195	0	10	5	0	0	8
G2	95	0	0	10	0	0	0
G3	10	10	0	10	0	20	0
total	300	10	10	25	0	20	8
Price	$35	$6	$2	$5	$5	$5	$0

Marginal price is the incremental bid cost (the minimum objective function value) of meeting 1 extra MW of requirement.

For example, if upward flexible ramping requirement increased by 1, the changes to the optimal schedule is

gen	Energy schedule	Reg up schedule	Reg down schedule	Spin schedule	Non Spin schedule	Flex up schedule	Flex down schedule
G1	-1 ($30)	0	0	+1 ($0)	0	0	0
G2	+1 ($35)	0	0	-1 ($0)	0	+1 ($0)	0
G3	0	0	0	0	0	0	0

RTPD 15-minute interval settlement

Payment to flexible ramping providers

gen	FRU schedule	FRD schedule	payment
G1	0	8	0.25*(0*5+8*0) = $0
G2	0	0	0.25*(0*5+0*0) = $0
G3	20	0	0.25*(20*5+0*0) = $25
total	20	8	0.25*(20*5+8*0) = $25

Charge to flexible ramping requirement setters

uncertainty	upward	downward	charge
load	15	5	0.25*(15*5+5*0) = $18.75
variable energy resources	5	3	0.25*(5*5+3*0) = $6.25
total	20	8	0.25*(20*5+8*0) = $25

The ISO is revenue neutral

RTD realized uncertainties

Realized total uncertainty	upward	downward
RTD1	3	0
RTD2	18	0
RTD3	6	0

Assume

- Resources follow instructions

Procured flexible ramping products are only allowed to meet the realized uncertainties.

Some insights

- G2 is cheaper than G3, so G2 will be dispatched for energy before G3
- G2 can only ramp 5 MW per 5-minute RTD interval
- If the ramp need due to realized total uncertainty is less than or equal to 5 MW for the next RTD interval, G2 will be able to fully cover it without deploying G3's awarded flexible ramping products
- If the ramp need due to realized total uncertainty is greater than 5 MW for the next RTD interval, G2 will be unable to fully cover it, so G3's awarded flexible ramping products have to be deployed to cover the uncertainty that is beyond 5 MW

RTD deployment

RTD1

3 MW of realized uncertainty

gen	energy	flex ramp up	flex ramp down
G1	195	0	8
G2	98	0	0
G3	10	20	0

- G2 is able to cover the 3 MW uncertainty realization in RTD1
- G3 keeps full awarded flexible ramping up capability of 20 MW
- RTD1 LMP is $35 set by G2's bid

RTD2

18 MW of realized uncertainty

gen	energy	flex ramp up	flex ramp down
G1	195	0	8
G2	103	0	0
G3	20	10	0

- G2 is only able to cover another 5 MW uncertainty realization from RTD1 due to ramp limitation
- The rest of the realized uncertainty is covered by deploying 10 MW of G3's upward flexible ramping, so G3 has 10 MW upward flexible ramping product left
- RTD2 LMP is $50 set by G3's bid

RTD3

6 MW of realized uncertainty

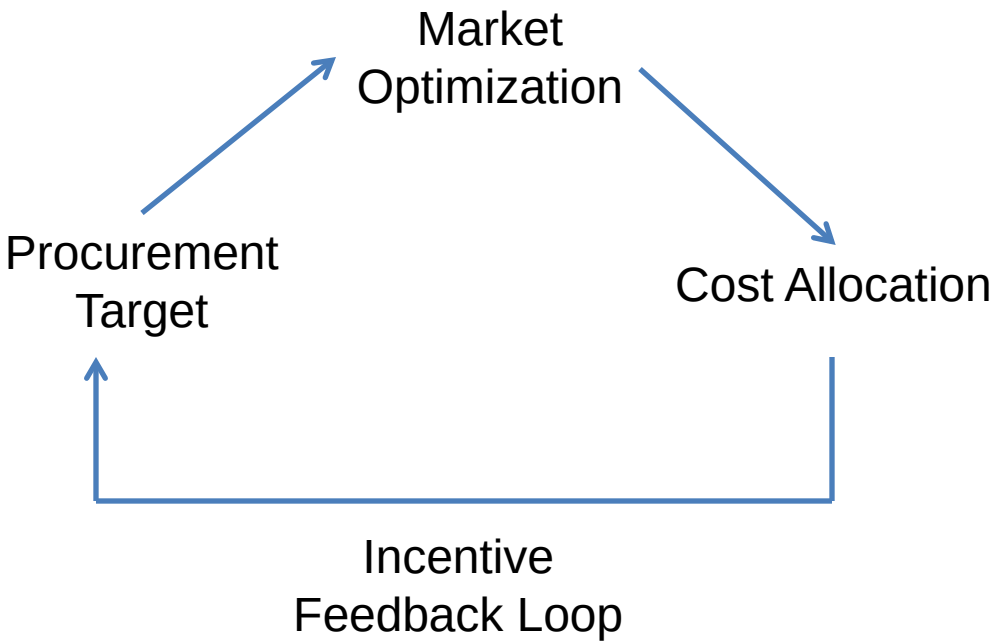
gen	energy	flex ramp up	flex ramp down
G1	195	0	8
G2	101	0	0
G3	10	20	0

- G2 is able to fully cover the 6 MW uncertainty realization in RTD3 with 10 minutes ramping
- G3's upward flexible ramping capability is fully restored in RTD3
- RTD3 LMP is $35 set by G2's bid

Observations from the example

- Procured flexible ramping product will not be deployed more than the total amount of realized uncertainties
- If there is cheaper energy from the rest of the dispatchable fleet, the ramping capability from the cheaper fleet will be utilized before procured flexible ramping product is deployed
- Procured flexible ramping product can be restored if the ramping need drops

Vision - cost allocation should create correct incentives to lower procurement target of operating reserves

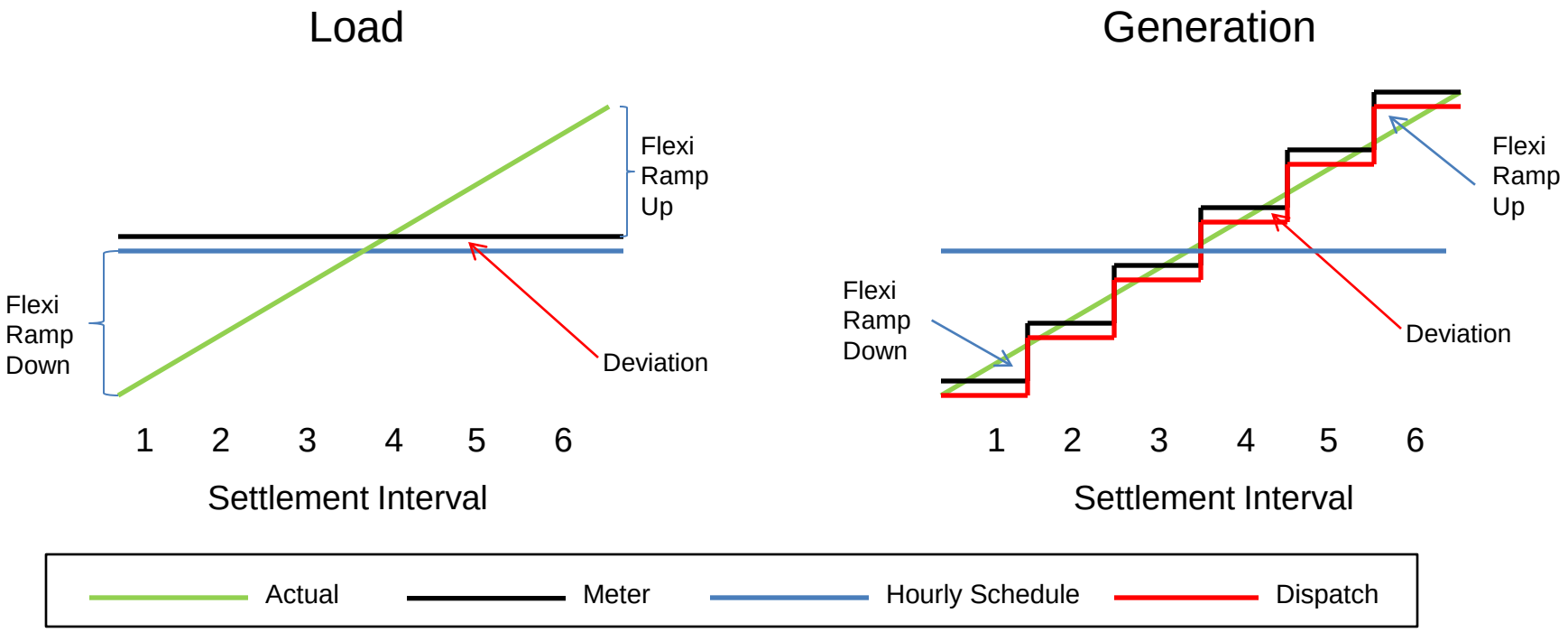


1. Profit maximizing behavior by resource in energy market
2. Data used to evaluate bilateral transactions

Phased approach starting with flexible ramping product

- Use existing settlement and metering data available to allocate flexi-ramp product costs as close as possible to vision
  - 5 min deviations more accurate representation of how procurement target calculated, but not available
  - No alignment between meter interval for load and generation
    - Generation meter is based upon 10 min interval
    - Load meter is netted hourly
- Alignment between schedule, meter and dispatch interval necessary for more robust cost allocation designs

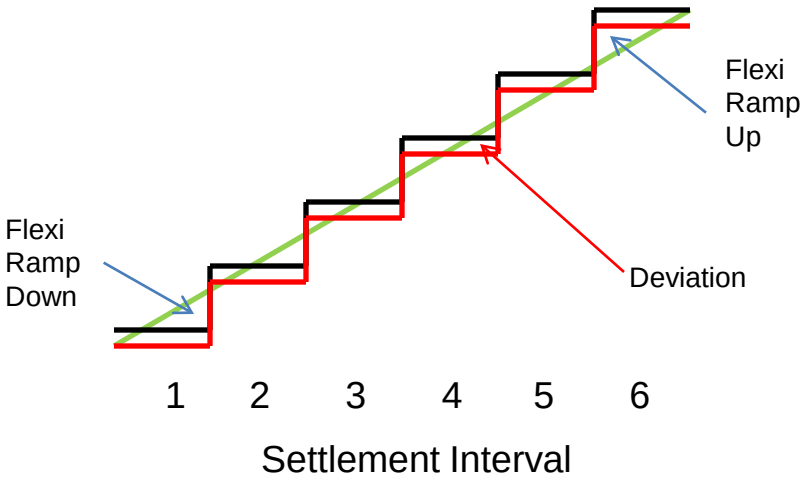
Meter granularity affects proper cost allocation if applied to deviations



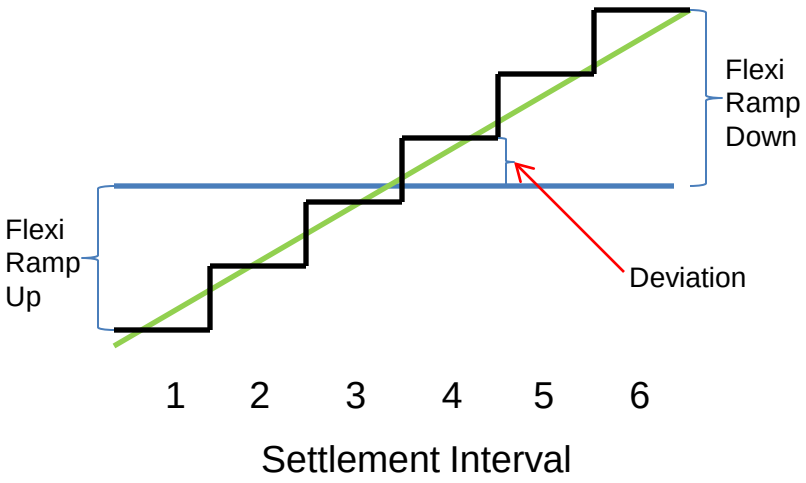
Load and Generation have equivalent measured deviations, but Load is a larger driver of flexi-ramp procurement.

RT self-schedules by Generation affects proper calculation of deviations

Generation – Economic Dispatch



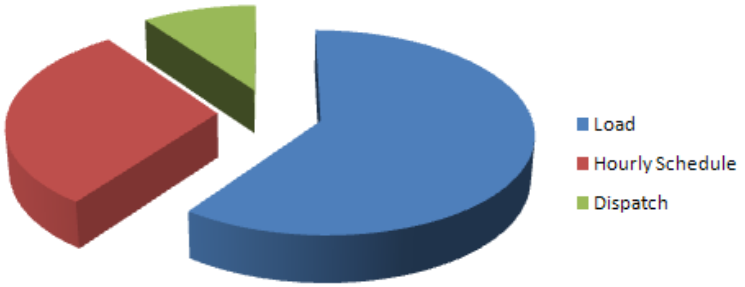
Generation – RT Self Schedule



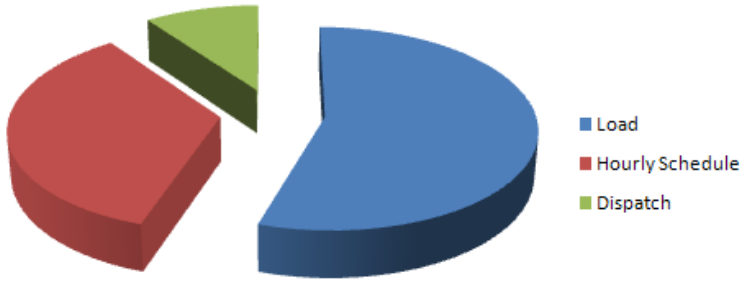
Real-time self schedules and economic dispatch require different reference point to measure deviations

Cost Allocation differs by bucket

Flexi-Ramp Up



Flexi-Ramp Down



Bucket	Allocation
UP - Load	Measured Demand (Metered Load + Exports)
UP – Hourly Schedule	Negative Uninstructed Imbalance Energy 2 Negative Operational Adjustments 1 & 2 (Imports)
UP – Dispatch	Negative Uninstructed Imbalance Energy 1
DOWN – Load	Measured Demand (Metered Load + Exports)
DOWN – Hourly Schedule	Positive Uninstructed Imbalance Energy 2 Positive Operational Adjustments 1 & 2 (Imports)
DOWN – Dispatch	Positive Uninstructed Imbalance Energy 1

Cost Allocation Example

- Total Flexi Ramp Up cost = $10,000 for the month
- Procurement driven 60% by Load, 30% by Hourly Deviations, 10% by Dispatch Deviations
- Flexi Ramp Up: Load = $6,000, Hourly Deviations = $3,000, Dispatch Deviations = $1,000
- Assume total UIE1 = 500MWh, if a resource had 50MWh of UIE1 over the month, it would be allocated 10% of the Dispatch Deviations or $100

Examples of UIE1 and UIE2 – Resource with RTD dispatch

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Day Ahead Schedule (DA)	100	100	100	100	100	100	100	100
Real Time Self Schedule (RT SS)	0	0	0	0	0	0	0	0
Instructed Imbalance Energy (IIE)	10	10	10	10	-10	-10	-10	-5
Dispatch (DA + RT SS + IIE)	110	110	110	110	90	90	90	95
Meter	110	100	90	120	90	80	100	110
Imbalance Energy (Meter - DA)	10	0	-10	20	-10	-20	0	10
Imbalance Energy - IIE - RT SS	0	-10	-20	10	0	-10	10	15
Uninstructed Imbalance Energy 1	0	-10	-10	0	0	0	10	5
Uninstructed Imbalance Energy 2	0	0	-10	10	0	-10	0	10
Uninstructed Imbalance Energy	0	-10	-20	10	0	-10	10	15

Deviations applied to UIE1 up to IIE
Remainder is applied to UIE2

Examples of UIE1 and UIE2 – Resource with RT self schedule

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Day Ahead Schedule (DA)	0	0	0	0	0	0	0	0
Real Time Self Schedule (RT SS)	100	100	100	100	100	100	100	100
Instructed Imbalance Energy (IIE)	0	0	0	0	0	0	0	0
Dispatch (DA + RT SS + IIE)	100	100	100	100	100	100	100	100
Meter	110	100	90	120	90	80	100	110
Imbalance Energy (Meter - DA)	110	100	90	120	90	80	100	110
Imbalance Energy - IIE - RT SS	10	0	-10	20	-10	-20	0	10
Uninstructed Imbalance Energy 1	0	0	0	0	0	0	0	0
Uninstructed Imbalance Energy 2	10	0	-10	20	-10	-20	0	10
Uninstructed Imbalance Energy	10	0	-10	20	-10	-20	0	10

All deviations are UIE2

Flexible Ramping procurement target is forecasted based upon historical variability & uncertainty, however

- Actual 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
- But, 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

Two stage allocation using generation monthly rate based on actual procurement costs and deviations

- Flexible ramping costs allocated to measured demand
- Determine the deviation monthly rate for Supply
  - Sum over month flexi-ramp procured because of generation
  - Denominator calculated by gross sum of deviations over month
  - Positive deviations charged DOWN rate at end of month
  - Negative deviations charged UP rate at end of month
- Costs collected from generation allocated to measured demand at end of month

Other items

- Publish Flexi-Ramp statistics in daily market watch
  - Cost to date, deviations to date, current rate per deviation
- Allow Inter-SC trades of flexi-ramp obligation
  - Currently Daily functionality, would require new Monthly functionality

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	12/12/11
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

Questions:

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