Flexible Ramping Products and Cost Allocation

Second Revised Straw Proposal, January 12, 2012

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and
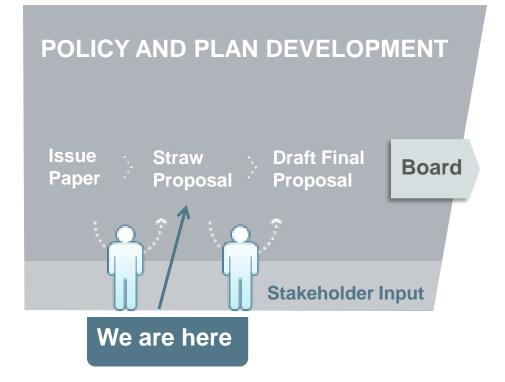Donald Tretheway
Senior Market Design and Policy Specialist

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 – 3:15	Product Design and Examples cont.	Lin Xu
3:15 – 3:30	Break	All
3:30 – 3:45	Cost Allocation	Don Tretheway
3:45 – 4:00	Next Steps	Chris Kirsten

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ISO Policy Initiative Stakeholder Process

What is new in the second revised straw proposal?

- Real-time procurement in RTD instead of RTPD
- Implicit bidding: a resource with an economic energy bid will be assumed to bid zero $/MWh for flexible ramping unless it submits an explicit flexible ramping bid
- Comprehensive examples that cover the day-ahead and real-time markets
- Cost allocation excludes metered subsystems that self manage variability and uncertainties

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
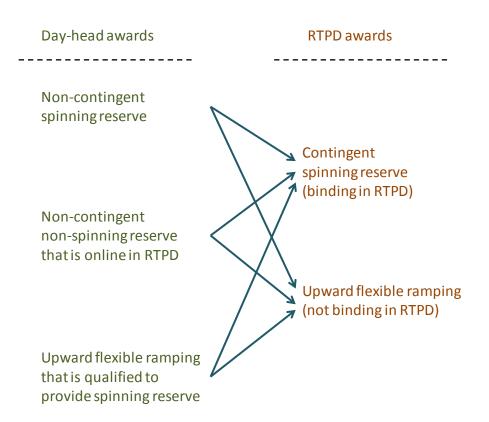   - Uninstructed deviation

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
- Allow explicit flexible ramping bids (must have economic energy bids)
  - A resource that has economic energy bids but no explicit flexible ramping bid will be assumed to bid zero $/MWh for flexible ramping
- Flexible ramping procurement process
  - Co-optimized with energy and ancillary services in the day-ahead market. The procurement is financially binding
  - Co-optimized with energy and ancillary services in RTPD to create headroom. The headroom is not financially binding.
  - Co-optimized with energy in RTD. The procurement is financially binding.
  - Requirement based on imbalance distribution
    - Being able to cover the imbalance with high confidence level (e.g. day-ahead at 60%, RTPD at 95%, and RTD at 95%)
    - Allow requirement relaxation at appropriate penalty price (step penalty function)

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Flexible ramping in RTPD

- Create flexible ramping headroom on a 15-minute interval basis

- Day-ahead flexible ramping awards will be protected by penalty prices

- Determine conversions between non-contingent spinning reserve and upward flexible ramping

  – Only apply to day-ahead awards

  – Spinning reserve converted from day-ahead flexible ramping is financially binding

  – Flexible ramping converted from day-ahead non-contingent spinning reserve is not financially binding in RTPD, but will be re-evaluated in RTD

Day-head awards

RTPD awards

Non-contingent spinning reserve

Non-contingent non-spinning reserve that is online in RTPD

Upward flexible ramping that is qualified to provide spinning reserve

Contingent spinning reserve (binding in RTPD)

Upward flexible ramping (not binding in RTPD)

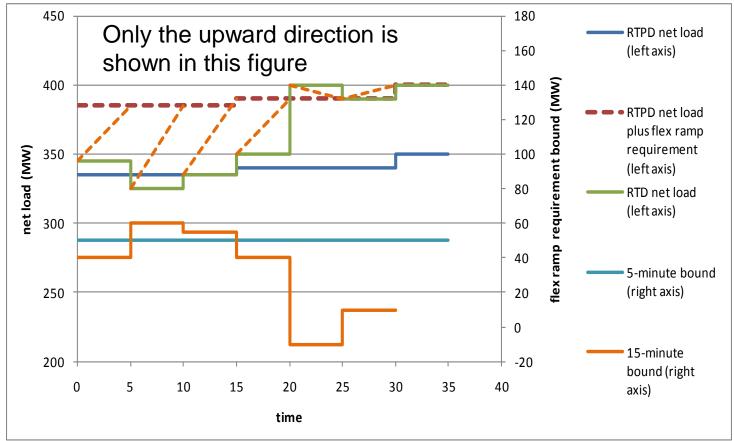California ISO
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RTD flexible ramping procurement

- Imbalance differences are fully realized for the binding RTD interval, but are not fully realized for the future intervals
- The energy and flexible ramping will be fully re-co-optimized
  - Previously procured flexible ramping capability will be fully released for dispatch in response to the realized imbalance difference
  - Flexible ramping capability will be re-procured for handling future variability and uncertainties that have not been realized yet
    - The binding interval requirement is based on how much the net load in the next RTD interval can change from the binding RTD interval
    - The binding interval procurement is financially binding
- Day-ahead flexible ramping award is assumed to have zero $/MWh cost

Calculating RTD requirements

Only the upward direction is shown in this figure

Legend:
- RTPD net load (left axis)
- RTPD net load plus flex ramp requirement (left axis)
- RTD net load (left axis)
- 5-minute bound (right axis)
- 15-minute bound (right axis)

- 15-minute bound is the RTPD load plus RTPD requirement for the next RTD interval minus the net load of the current RTD interval
- 5-minute bound is the most recent estimate about how much the net load can change from the current RTD interval to the next RTD interval, and should not exceed the RTPD requirement
- RTD requirement is bounded by both the 15-minute bound and the 5-minute bound

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RTD flexible ramping price and opportunity cost

- Providing flexible ramping in the binding RTD interval may incur an opportunity cost (for not being able to provide energy)

- The opportunity cost has been included in the RTD flexible ramping price as a result of the co-optimization

- Procuring flexible ramping in RTD allows opportunity cost to be settled properly

  - For each RTD interval, flexible ramping capacity and energy dispatch are mutually exclusive

  - For a resource providing flexible ramping, the lost opportunity of providing energy is truly lost as the RTD dispatch is the final binding dispatch

  - Because there is no false lost opportunity in RTD, there is no false opportunity cost payment in RTD

Example - day-ahead market

gen	Energy	Reg-up	Reg-down	Spinning reserve	Non-spin reserve	Flex-ramp up	Flex-ramp down
G1	20						
G2	190						
G3	10						
G4	10						
G5	35					30	30
G6	1			9 non-contingent			
G7	15	10	10	11 non-contingent			

Day-ahead awards

Only market results are provided. Optimization details are omitted.

Day-ahead prices

Product	Shadow Price ($/MWh)	Marginal Price ($/MWh)
Energy	40	40
Regulation-up	1	2
Regulation-down	1	1
Spinning reserve	1	1
Non-spinning reserve	0	0
Upward flexible ramping product	2	2
Downward flexible ramping product	2	2

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Example - RTPD

gen	EN Bid	RU bid	RD bid	SP bid	NS bid	FRU bid	FRD bid	En init	RU init	RD init	SP init	NS init	FRU init	FRD init
G1	25	10	10	10	10	1.4	3	20	0	0	0	0	0	10
G2	30	1.1	1.2	0	0	4	2	180	10	10	0	0	10	0
G3	35	3	3	0	0	3	1	89	10	0	0	0	0	0
G4	50	2	2	0	0	2.3	3	10	0	0	0	0	5	0
G5	53	No	No	No	No	SS	SS	30	0	0	0	0	30	30
G6	60	No	No	SS	No	No	No	1	0	0	9	0	0	0

EN – energy
RU – regulation up
RD – regulation down
SP – spinning reserve
NS – non-spinning reserve
FRU – flexible ramping up
FRD – flexible ramping down
No – no bid
SS – self schedule/provision

Note: G7 is offline due to forced outage

gen	Pmin	Pmax	operational ramp rate	regulation ramp rate
G1	10	45	5	5
G2	10	200	3	3
G3	10	300	1	1
G4	10	21	8	8
G5	5	65	6	6
G6	1	10	1	1

Requirements
- Load 340 MW
- Reg-up 10 MW
- Reg-down 10 MW
- Spinning 20 MW
- Non-spinning 0 MW
- Upward flexible ramping 50 MW
- Downward flexible ramping 40 MW

Example - RTPD solution

gen	Energy	Reg-up	Reg-down	Spinning reserve	Non-spin reserve	Flex-ramp up	Flex-ramp down
G1	45						10
G2	175	10	10	5		5	
G3	74			10			
G4	10			1		10	
G5	35					30	30
G6	1			4		5	

Replace G7's day-ahead regulation awards

Replace G7's day-ahead spinning reserve award and G6's day-ahead award that is converted into flex-ramp

G6's 5 MW DA non-contingent spinning reserve award is converted into upward flexible ramping award

Product	Shadow Price ($/MWh)	Marginal Price ($/MWh)
Energy	30	30
Regulation-up	1.1	1.1
Regulation-down	1.2	1.2
Spinning reserve	0	0
Non-spinning reserve	0	0
Upward flexible ramping product	2.3	2.3
Downward flexible ramping product	1.4	1.4

It is economic to convert spinning reserve to upward flexible ramping

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Example - RTD imbalance realizations and requirements

		RTPD1			RTPD2			RTPD3
		RTD1	RTD2	RTD3	RTD4	RTD5	RTD6	RTD7
	RTPD net load	335	335	335	340	340	340	350
	RTD realization	10	-10	0	10	60	50	50
	RTD net load	345	325	335	350	400	390	400
upward	RTPD requirement	50	50	50	50	50	50	50
	15 minute bound	40	60	55	40	-10	10	...
	5 minute bound	50	50	50	50	50	50	50
	RTD requirement	40	50	50	40	-10	10	...
downward	RTPD requirement	40	40	40	40	40	40	40
	15 minute bound	60	40	45	60	110	90	...
	5 minute bound	40	40	40	40	40	40	40
	RTD requirement	40	40	40	40	40	40	...

Consider RTD4:
- RTPD requires 50 MW headroom
- Realized imbalance difference is 10 MW
- Upward 15-minute bound is 40 MW (=340+50-350)
- Upward RTD requirement is 40 MW
- Downward RTD requirement is 40 MW

Example - RTD solution

gen	Energy	Lower operating limit	Upper operating limit	Flex-ramp up	Flex-ramp down
G1	45	10	45		25 (+15)
G2	185 (+10)	20	185	0 (−5)	
G3	94 (+20)	10	290		5 (+5)
G4	15 (+5)	10	20	5 (−5)	5 (+5)
G5	10 (−25)	5	65	30	5 (−25)
G6	1	1	6	5	

Numbers in parentheses are changes from RTPD

Product	Marginal Price ($/MWh)
Energy	49
Upward flexible ramping product	3.3
Downward flexible ramping product	4

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Example – flexible ramping compensation

	Day-ahead market settlement (award times price)		RTD incremental award (5/60 times award times price)	
gen	flex-ramp up (price = $2)	flex-ramp down (price = $2)	Flex-ramp up (price = $3.3)	Flex-ramp down (price = $4)
G1				5/60*25*4
G2				
G3				5/60*5*4
G4			5/60*5*3.3	5/60*5*4
G5	30*2	30*2	5/60*0*3.3	5/60*0*4
G6			5/60*5*3.3	
G7				

Flexible ramping compensation summary

- Day-ahead
  - Day-ahead flexible ramping award settled at day-ahead price
- RTPD
  - Spinning reserve converted from day-ahead upward flexible ramping settled at RTPD spinning reserve price minus RTPD upward flexible ramping price
  - Flexible ramping headroom in RTPD including the amount converted from day-ahead non-contingent spinning reserve is not settled in RTPD
- RTD
  - Incremental flexible ramping award from day-ahead award (the remaining amount if part of the day-ahead flexible ramping award has been converted into spinning reserve in RTPD) settled at RTD flexible ramping marginal price

Cost allocation changes from Straw Proposal

- MSS Load Following not included in allocation to measured demand

- Holistic cost allocation stakeholder initiative to begin in Q1'12

Next Steps

Item	Date
Post Straw Proposal	11/01/11
Stakeholder Meeting	11/07/11
Stakeholder Comments	11/14/11
Post Revised Straw Proposal	11/28/11
Stakeholder Meeting	12/05/11
Stakeholder Comments	12/13/11
Post Second Revised Straw Proposal	01/05/12
Stakeholder Meeting	01/12/12
Stakeholder Comments	01/19/12
Post Draft Final Proposal	02/06/12
Stakeholder Call	02/13/12
Board of Governors Briefing	02/16/12
Stakeholder Comments	02/21/12
Board of Governors Decision	03/22/12

- Submit comments to FRP@caiso.com

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