Technical Workshop on Flexible Ramping Products

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Lin Xu, Ph.D.
Senior Market Development Engineer

Don 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 – 2:45	Product Design and Examples cont.	Lin Xu
2:45 – 3:00	Break	All
3:00 – 3:45	Cost Allocation	Don Tretheway
3:45 – 4:00	Next Steps	Chris Kirsten

Flexible ramping product

- What are flexible ramping products?
  - 5-minute upward and downward ramping capability
  - If the market clearing interval is longer than 5 minutes, then the award is the average (sustainable) 5-minute ramping capability over the market clearing interval
    - In DA, a 600 MW resource can provide at most 600/12=50 MW flexible ramping
    - In RTUC, a 600 MW resource can provide at most 600/3=200 MW flexible ramping
- Goal
  - Improve real-time dispatch flexibility
    - Handle net load variations happening on 5-minute time frame in the market
    - Reduce power balance violations in RTD
  - Manage market cost effectiveness

Procurement target

- Explicit approach
  - Assign a procurement target directly (like ancillary services) before the optimization
  - Requirement based on a certain confidence interval of historical net load variation
  - Pros: simple and direct
  - cons: needs to be adjusted frequently to manage cost effectiveness
- Implicit approach
  - Estimate benefits of maintaining flexible ramping capability at various levels, and translate the benefits into per MW prices
  - Construct a flexible ramping demand curve based on the beneficial capacities and prices to use in the optimization
  - Procurement amount determined in optimization
  - Pros: procurement amount driven by cost effectiveness
  - Cons: more complicated benefit analysis method

Comparing the procurement in the explicit approach and the implicit approach

Explicit

- DA – up X^{60}, down Y^{60}
- RTUC – up RX^{95}, down RY^{95}
- RTD – up $\min\{X^{95}, RX^{95} - R\}$, down $\min\{Y^{95}, RY^{95}+R\}$

$[-Y^{95}, X^{95}]$ is the 95% confidence interval for 5-minute net load variation between intervals

$[-Y^{60}, X^{60}]$ is the 60% confidence interval for 5-minute net load variation between intervals

R = RTD net load – RTUC net load

$[-RY^{95}, RX^{95}]$ is the 95% confidence interval for R

Implicit

- DA – up $f(\cdot)$, down $g(\cdot)$
- RTUC – up $f(\cdot)$, down $g(\cdot)$
- RTD – up $f(\cdot)$, down $g(\cdot)$

$f(\cdot)$ is the upward flexible ramping demand curve

$g(\cdot)$ is the downward flexible ramping demand curve

Although the demand functions can be used in DA, RTUC and RTD, the actual procurement amounts are generally different

Penalty prices

- The penalty prices serve different purposes
  - In the explicit approach
    - the penalty prices serve as market price caps to set scarcity prices when the fixed procurement target cannot be met
    - the penalty prices are relatively high
  - In the implicit approach
    - the penalty prices serve as demand curves to determine the procurement target in the optimization
    - the penalty prices are relatively low
- Technically, the difference between the explicit approach and the implicit approach is very small
  - That is, how to set the penalty prices

Dispatch flexible ramping capability in RTD

- Explicit approach
  - Release flexible ramping capacity based on the realized net load imbalance amount in RTD without penalty
  - Treat capacity constrained and ramp constrained indifferently
  - May produce lower energy price
    - At the cost of possibly more procurement in RTUC than in RTD
- Implicit approach
  - Release capacity constrained capacity with penalty equal to opportunity cost
  - May produce higher energy price due to protecting the capacity constrained flexible ramping capacity

Obtain flexible ramping capability

- Flexible ramping capability can be created/maintained by
  - Economic dispatch
    - positioning units at fast ramping range
    - dispatching slow capacity to meet energy target and keeping fast capacity to provide flexible ramping
    - using ramp constrained flexible ramping capacity to meet net load variation and keeping capacity constrained flexible ramping capacity
  - Unit commitment
    - committing more resources if it is less expensive than moving the resource around in the economic dispatch

Procure flexible ramping capability the in day-ahead market

- It may be beneficial to procure at least part of needed flexible ramping capability in the day-ahead market
  - If It is more economic than procuring it in real-time
  - Long start units can be committed to provide flexible ramping
- Open issues
  - Cost effectiveness: how much to procure in day-ahead
  - What if it is over-procured in day-ahead or the DA award cannot be held in real-time due to instructed incremental dispatch?
    - Flexible ramping capacity buy-back in real-time
  - Evaluating expected real-time energy dispatch cost in the day-ahead optimization vs locking day-ahead energy offer
  - Integrate RUC into IFM

False opportunity cost payment vs double payment

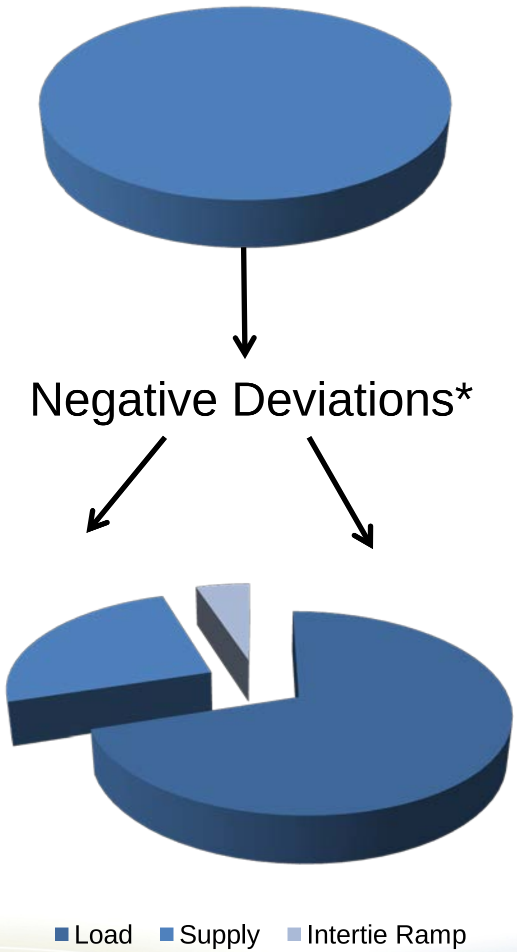
- Double payment
  - The same capacity received both capacity payment and energy payment due to energy dispatch
  - For example, dispatched RUC capacity receives double payment
- False opportunity cost payment
  - The same capacity receives double payment, and the capacity price includes a false energy lost opportunity cost
  - False opportunity cost payment should be prevented
    - That is why ISO does not settle the RTUC flexible ramping headroom
    - Does the DA flexible ramping awarded capacity that is dispatched for energy in RTD receive false opportunity cost payment?
      - Controversial
      - Flexible ramping buy-back in RTD can resolve it

Cost Allocation of Flexible Ramping Product

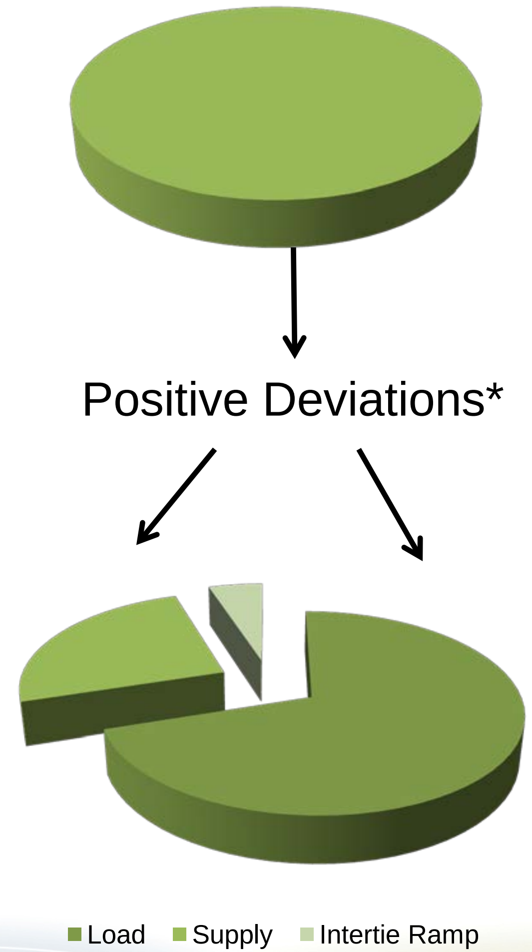
- Load 15 Minute Profile Analysis
- Demand and Supply UIE Analysis
- Flexible Ramping Constraint Hourly Costs
- Variability Only Cost Drivers – Static Ramps
- Treatment of Outages
- Additional Data Analysis

Allocate flexible ramping product costs consistent with guiding principles

Flexible Ramping Up



Flexible Ramping Down



* Sum of each 10 minute interval

Summary of cost allocation under development

		Profile	Baseline	Actual	Deviation	Allocation
1	Load	ISO 15 Minute Forecast	Convert Profile to 10 Min	ISO 10 Minute Observed Demand	Net Across LSEs	Load ratio share
2	Variable Energy Resource	Resource's 15 Minute Forecast	Convert Profile to 10 Min	10 Minute Meter	Net Across All Supply Resources	Gross Deviation
	Internal Generation	N/A	Dispatch	10 Minute Meter		Gross UIE
	Interties Operational Adjustments	N/A	N/A	Deemed Delivered		Gross OA
3	Interties Ramp	20 Minute Ramp Modeled	Convert Profile to 10 Min	Assumed Delivered	Net Across SCs	Gross SC Deviation

- Monthly re-settlement of cost allocation
- Functionality to assign costs at resource level

Load Profile since Flexible Ramping Constraint Implemented

	Flexible Ramping Up		Flexible Ramping Down	
MWh	Profile Deviations	Negative UIE	Profile Deviations	Postive UIE
January	36,568	304,259	138,325	108,648
February	38,397	214,127	105,877	83,993
March	220,243	237,123	185,604	109,537
April	260,563	TBD	252,632	TBD
May (up to 22nd)	194,372	TBD	186,337	TBD

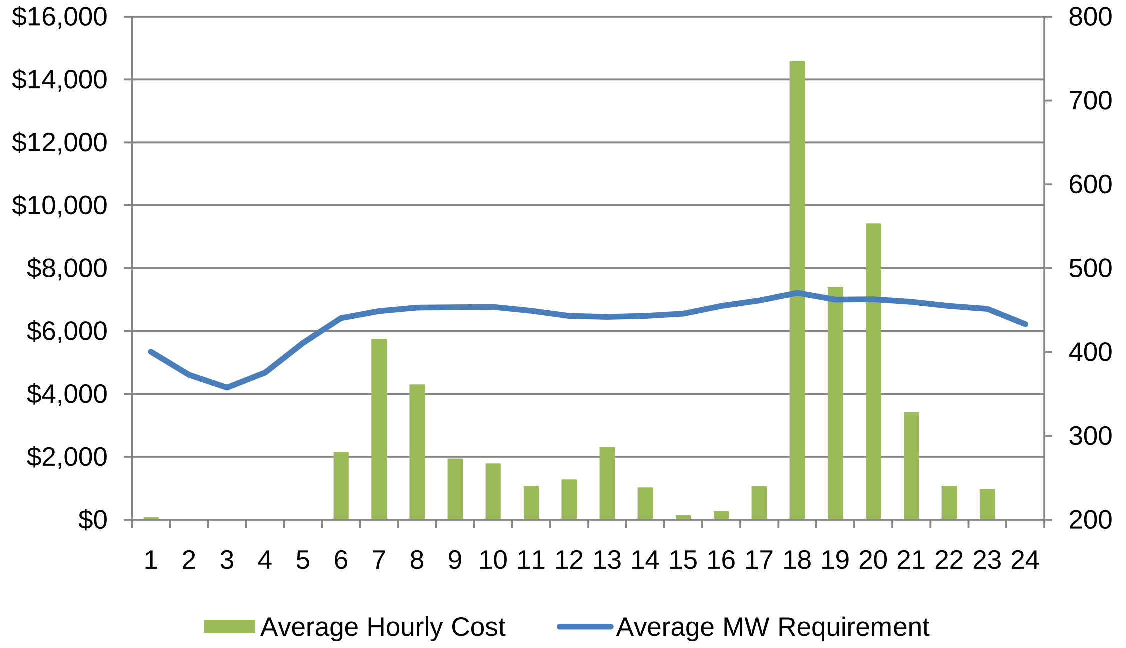
Gross Sum of UIE by Load and Supply

	Flexible Ramping Up				Flexible Ramping Down			
MWh	Demand	Supply	% Demand	% Supply	Demand	Supply	% Demand	% Supply
Jul-11	227,343	96,661	70%	30%	248,356	156,138	61%	39%
Aug-11	200,356	44,293	82%	18%	195,297	136,475	59%	41%
Sep-11	167,243	111,717	60%	40%	309,106	87,601	78%	22%
Oct-11	157,432	66,184	70%	30%	173,060	94,042	65%	35%
Nov-11	202,822	55,494	79%	21%	144,795	98,588	59%	41%
Dec-11	256,398	46,140	85%	15%	93,456	95,527	49%	51%
Jan-12	304,259	24,389	93%	7%	108,648	157,168	41%	59%
Feb-12	214,127	58,458	79%	21%	83,993	101,024	45%	55%
Mar-12	237,123	78,925	75%	25%	109,537	90,209	55%	45%
Total	1,967,103	582,260	77%	23%	1,466,248	1,016,773	59%	41%

- Demand UIE is deviation to DA Schedule
- Supply UIE is deviation to Dispatch and DA Schedule
- Used existing settlement data, not FRP proposed measurement

Flexible Ramping Constraint Costs by Hour (January to March)

	Average MW Requirement	Total Cost	Average Hourly Cost
HE 01	400	$ 7,136	$ 78
HE 02	373	$ 2,549	$ 28
HE 03	357	$ -	$ -
HE 04	375	$ 10	$ 0
HE 05	411	$ -	$ -
HE 06	440	$ 196,147	$ 2,155
HE 07	449	$ 522,761	$ 5,745
HE 08	453	$ 391,416	$ 4,301
HE 09	453	$ 176,463	$ 1,939
HE 10	454	$ 163,007	$ 1,791
HE 11	449	$ 98,292	$ 1,080
HE 12	443	$ 116,843	$ 1,284
HE 13	442	$ 210,416	$ 2,312
HE 14	443	$ 93,867	$ 1,032
HE 15	446	$ 12,885	$ 142
HE 16	455	$ 24,749	$ 275
HE 17	462	$ 97,445	$ 1,071
HE 18	471	$ 1,327,341	$ 14,586
HE 19	463	$ 674,018	$ 7,407
HE 20	463	$ 857,866	$ 9,427
HE 21	460	$ 311,296	$ 3,421
HE 22	455	$ 97,828	$ 1,075
HE 23	451	$ 88,118	$ 979
HE 24	433	$ 94	$ 1
Total		$ 5,470,546	



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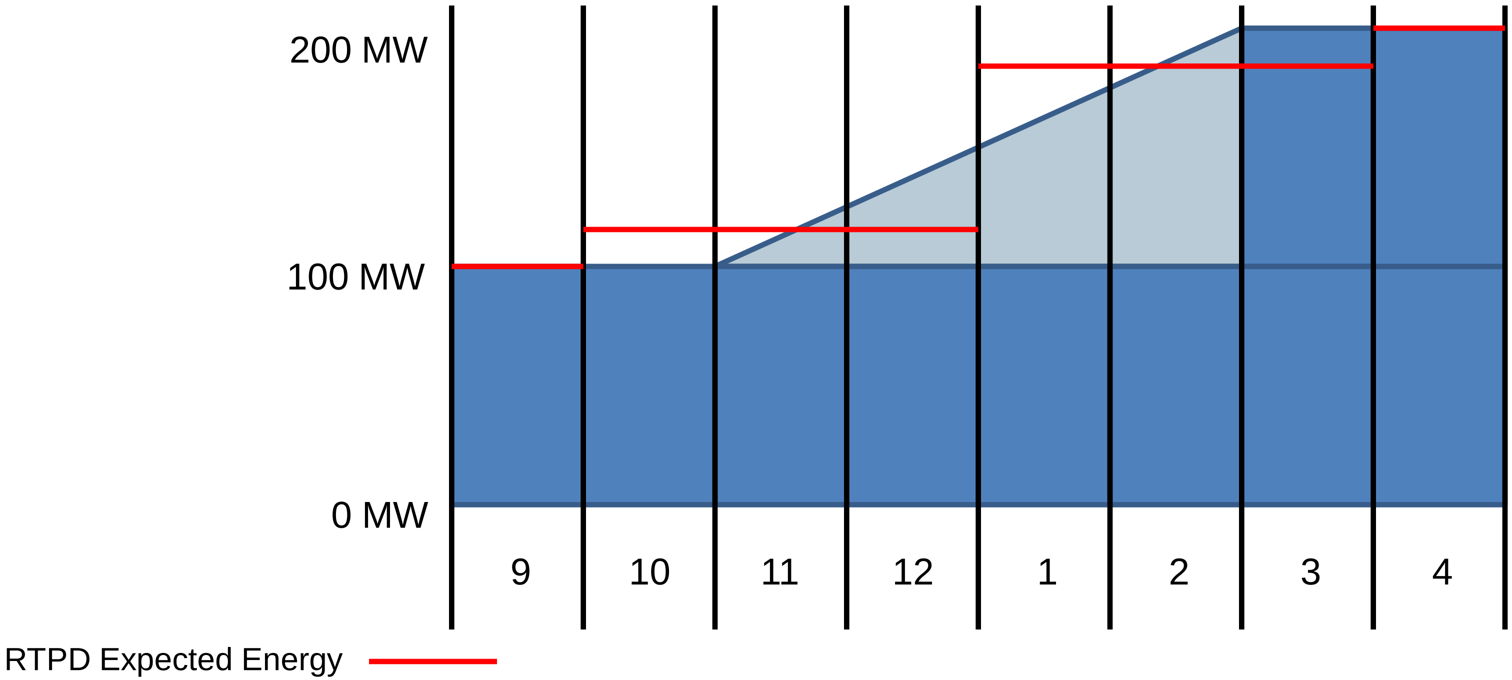
Intertie Static Resource Allocation as proposed in DFP



Intertie Static Schedule

	HE01						HE02					
	RTUC 3			RTUC 4			RTUC 1			RTUC 2		
	25.00			29.17			45.83			50.00		
	RTD 7	RTD 8	RTD 9	RTD 10	RTD 11	RTD 12	RTD 1	RTD 2	RTD 3	RTD 4	RTD 5	RTD 6
RTPD Expected Energy	8.33	8.33	8.33	9.72	9.72	9.72	15.28	15.28	15.28	16.67	16.67	16.67
Deemed Delivered	8.33	8.33	8.33	8.33	9.38	11.46	13.54	15.63	16.67	16.67	16.67	16.67
	Settlement 4		Settlement 5		Settlement 6		Settlement 1		Settlement 2		Settlement 3	
Expected Energy from RTPD	16.67		18.06		19.44		30.56		31.94		33.33	
Deemed Delivered	16.67		16.67		20.83		29.17		33.33		33.33	
Flexi-Ramp Up Allocation	0.00		1.39		0.35		1.74		0.00		0.00	
Flexi-Ramp Down Allocation	0.00		0.00		1.74		0.35		1.39		0.00	

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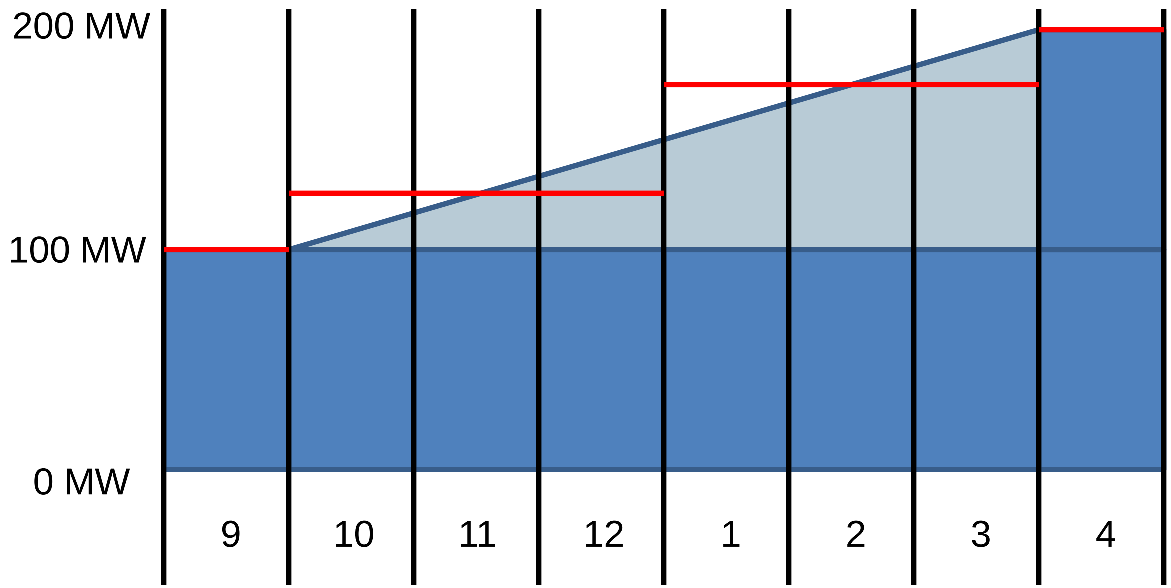
Internal Self-Schedule (followed ramp rate)



RTPD Expected Energy

Internal Generation Self Schedule - Following ramp rate

	HE01						HE02					
	RTUC 3			RTUC 4			RTUC 1			RTUC 2		
	25.00			31.25			43.75			50.00		
	RTD 7	RTD 8	RTD 9	RTD 10	RTD 11	RTD 12	RTD 1	RTD 2	RTD 3	RTD 4	RTD 5	RTD 6
RTPD Expected Energy	8.33	8.33	8.33	10.42	10.42	10.42	14.58	14.58	14.58	16.67	16.67	16.67
Instructed Energy (Actual)	8.33	8.33	8.33	9.03	10.42	11.81	13.19	14.58	15.97	16.67	16.67	16.67
	Settlement 4		Settlement 5		Settlement 6		Settlement 1		Settlement 2		Settlement 3	
RTPD Expected Energy	16.67		18.75		20.83		29.17		31.25		33.33	
Meter	16.67		17.36		22.22		27.78		32.64		33.33	
Flexi-Ramp Up Allocation	0.00		1.39		0.00		1.39		0.00		0.00	
Flexi-Ramp Down Allocation	0.00		0.00		1.39		0.00		1.39		0.00	
Instructed Energy	16.67		17.36		22.22		27.78		32.64		33.33	
Meter	16.67		17.36		22.22		27.78		32.64		33.33	
Uninstructed Energy	0.00		0.00		0.00		0.00		0.00		0.00	

Ramping Energy is considered instructed

Standard Ramping Energy (SRE)	IIE produced or consumed in the first two and the last two Dispatch Intervals due to hourly schedule changes. SRE is a schedule deviation along a linear symmetric 20-min ramp ("standard ramp") across hourly boundaries. SRE is always present when there is an hourly schedule change, including resource Start-Ups and Shut-Downs. SRE does not apply to Non-Dynamic System Resources (including Resource-Specific System Resources. SRE is not subject to settlement as shown in Section 11.5.1 of the CAISO Tariff.	SRE
Ramping Energy Deviation (RED)	IIE produced or consumed due to deviation from the standard ramp because of ramp constraints, Start-Up, or Shut-Down. RED may overlap with SRE, and both SRE and RED may overlap with DASE, but with no other IIE subtype. RED may be composed of two parts: a) the part that overlaps with SRE whenever the DOP crosses the SRE region; and b) the part that does not overlap with SRE. The latter part of RED consists only of *extra-marginal* IIE contained within the hourly schedule change band and not attributed to Exceptional Dispatch or derates. RED does not apply to Non-Dynamic System Resources (including Resource-Specific System Resources). RED is paid/charged the Real-Time LMP as reflected in Section 11.5.1 of the CAISO Tariff and it is included in BCR only for market revenue calculations as reflected in Section 11.8.1.4.5 of the CAISO Tariff.	RED

There is variability (RTD must dispatch resources to enable ramp, but no uncertainty.

Energy Settlement of De-rates or Outages

	Energy	Price	Financial Impact
Internal Generation – Day Ahead Schedule	Instructed	RTD	IFM-RTD
Internal Generation – Real Time Dispatch	Instructed	RTD	RTD-RTD
Import – Day Ahead Schedule	Operational Adjustment	RTD	IFM-RTD
Import – Incremental in HASP	Operational Adjustment	HASP	HASP-HASP
PIRP – Real-Time Self Schedule	Uninstructed	RTD	Monthly Netting
VER – 15 Minute Expected Output	N/A	N/A	None*

* Used for FRP Allocation Only

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Additional Data Analysis

- Comparison of Demand Allocation using Load Ratio Share or Gross Deviations
- Proxy for VER 15 Minute Expected Output Assuming Persistence
- Use of UDP threshold (5M or 3% Pmax) for supply allocation and assess need for second tier

Questions

Product design:
Lin Xu
lxu@caiso.com
916-608-7054

Cost Allocation:
Don Tretheway
dtretheway@caiso.com
916-608-5995