Flexible Ramping Product Technical Workshop

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Agenda

Time	Topic	Presenter
10:00 – 10:10	Introduction	Chris Kirsten
10:10 – 11:00	Design Decisions	Lin Xu
11:00 – 12:00	Modeling and Settlement Examples	Lin Xu
12:00 – 1:00	Lunch Break	
1:00 – 2:25	Modeling and Settlement Examples (Cont.)	Lin Xu
2:25 – 2:55	Cost Allocation Examples	Don Tretheway
2:55 – 3:00	Wrap-up and Next Steps	Chris Kirsten

Topics

- Design decisions
- Modeling and settlement examples
  - Requirement and demand curve
  - Combined IFM and RUC
  - Interactions between DA, RTUC and RTD
  - Settlement
- Cost allocation examples

Design decisions in response to stakeholder comments

- Allow resource to rebid incremental flex ramp in real-time
  - The ISO will assume the day-ahead FRP award has zero cost
  - A resource's real-time FRP bid applies to incremental procurement from day-ahead award
  - This design will prevent a resource from being paid worse off in real-time
- Regulation and flex ramp
- Model and settle flex ramp as 5-minute ramping capability
- Combined IFM and RUC
- Clarified PIRP not eligible for monthly netting if awarded FRD
- Cost allocation
  - VERs can submit their own 15 minute expected energy for FRP cost allocation, but will be monitored for gaming cost allocation
  - Internal self-schedules are in the supply category only
  - Gross UIE will be used to allocate within the supply category

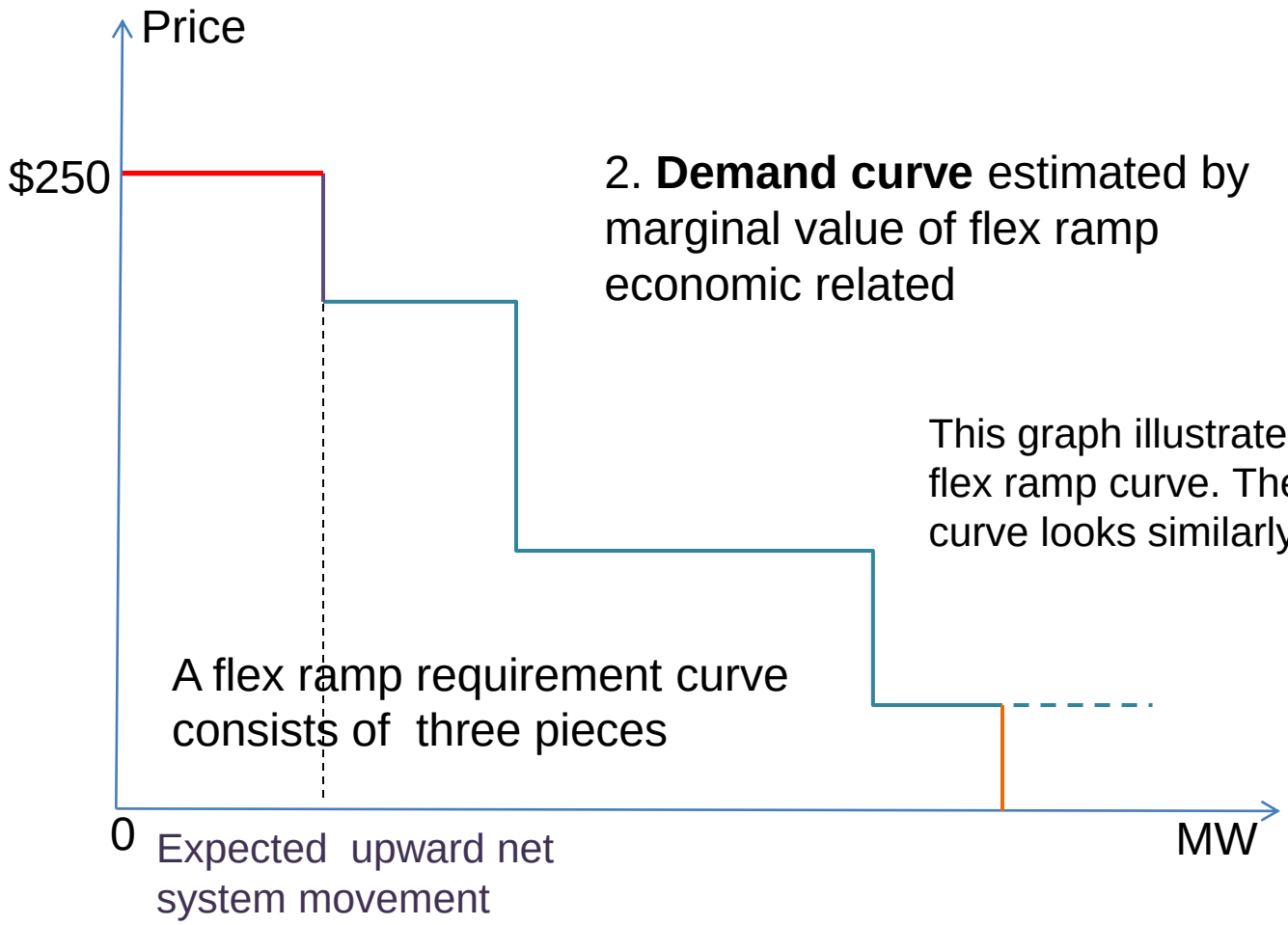
Regulation and flex ramp

- Option 1: bidding rule (ISO preferred)
  - Flex ramp bid should not exceed corresponding regulation bid
- Option 2: regulation participate as flex ramp
- Pros and cons:
  - Option 1: easy to implement, restricts bidding (does not seem to do any harm though)
  - Option 2: difficult to implement, gives the correct incentive without restricting bidding

Modeling and Settlement Examples

- Flex ramp demand curve
- Flex ramp in day-head market
  - IFM only
  - Combined IFM and RUC
- Flex ramp in RTUC
- Flex ramp in RTD
- Settlement

Concept: Flex Ramp Requirement and Demand Curve

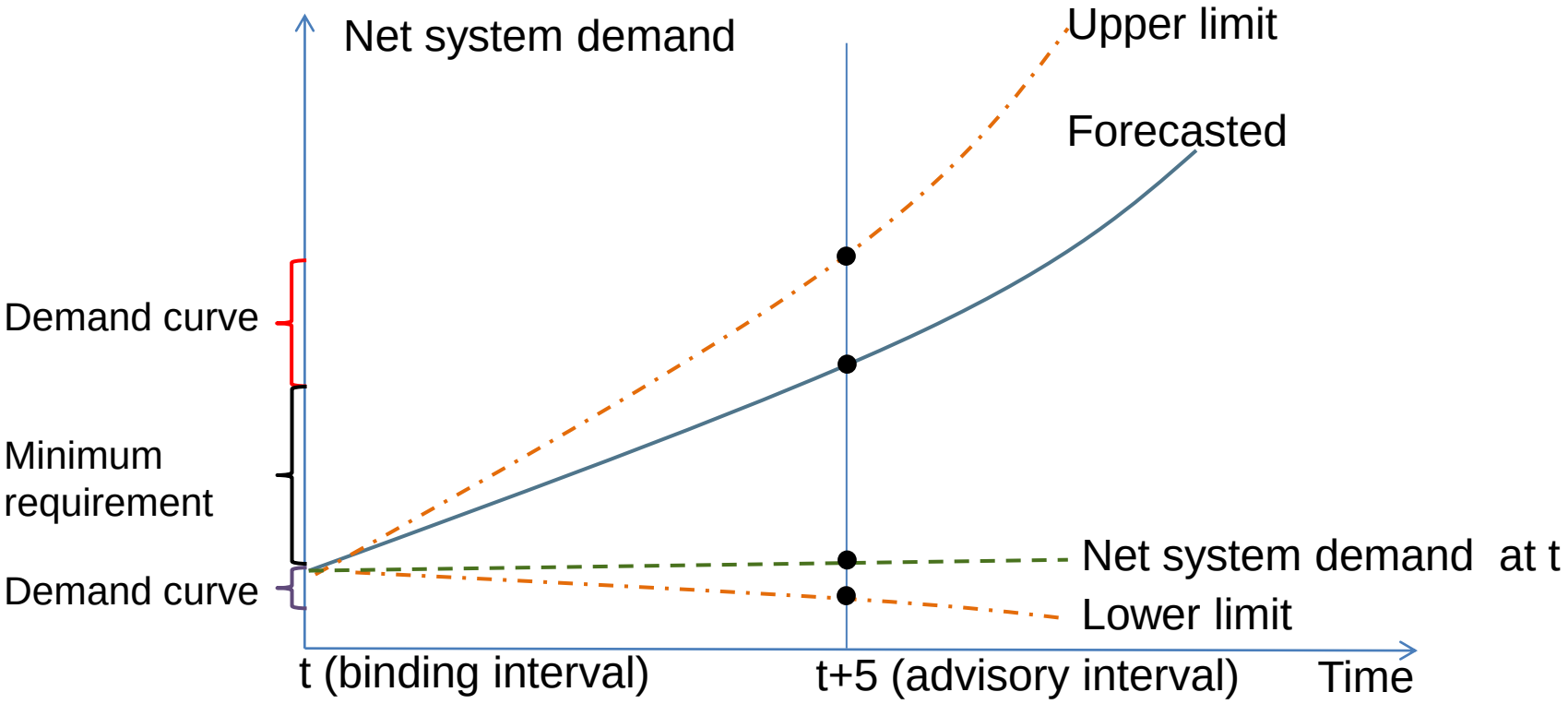


1. Minimum requirement
reliability related

3. **Maximum requirement**
statistical limit

Ramping requirement

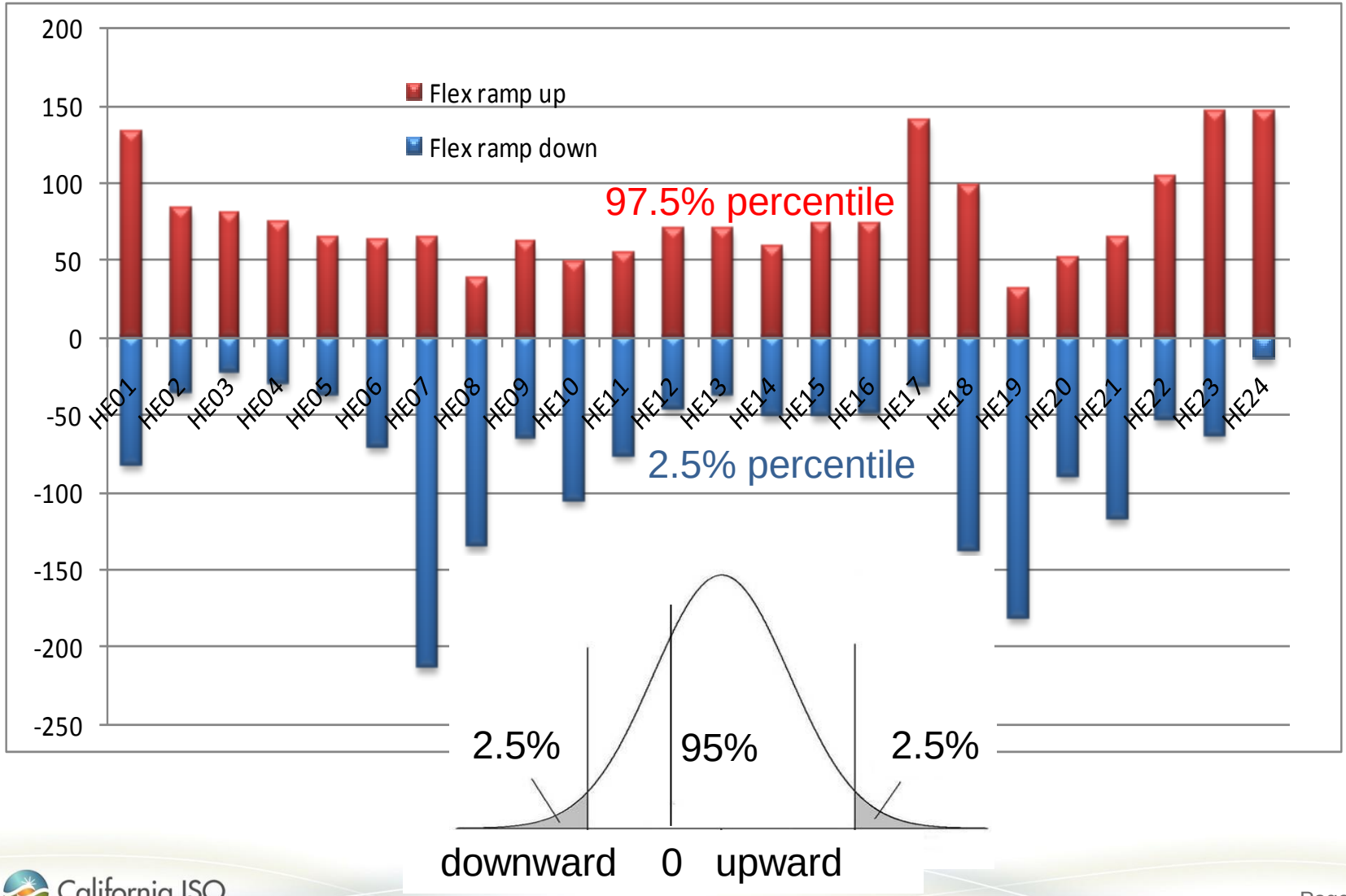
Net system demand = load + export – import – internal self-schedules - supply deviations



Real ramping need:

Potential net load change from interval t to interval t+5
(net system demand t+5 – net system demand t)

Example: 5-minute maximum ramping need (95% confidence interval) January to March 2012



Example: Power Balance Violation January to March 2011

PBV category	0 MW flex ramp		100 MW flex ramp		200 MW flex ramp		300 MW flex ramp	
	Prob.	Avg.	Prob.	Avg.	Prob.	Avg.	Prob.	Avg.
–200-0MW	2.67%	100.00	1.34%	50.00	0	0	0	0
0-100 MW	0.47%	48.27	0.25%	47.29	0.09%	50.22	0.28%	47.79
100-200 MW	0.25%	147.29	0.09%	150.22	0.28%	147.79	0%	0
200-300 MW	0.09%	250.22	0.28%	247.79	0%	0	0%	0
300-400 MW	0.28%	347.79	0%	0	0%	0	0%	0

Power balance violation (PBV) penalties (these values are interpolated from scheduling run parameters in the market optimization)

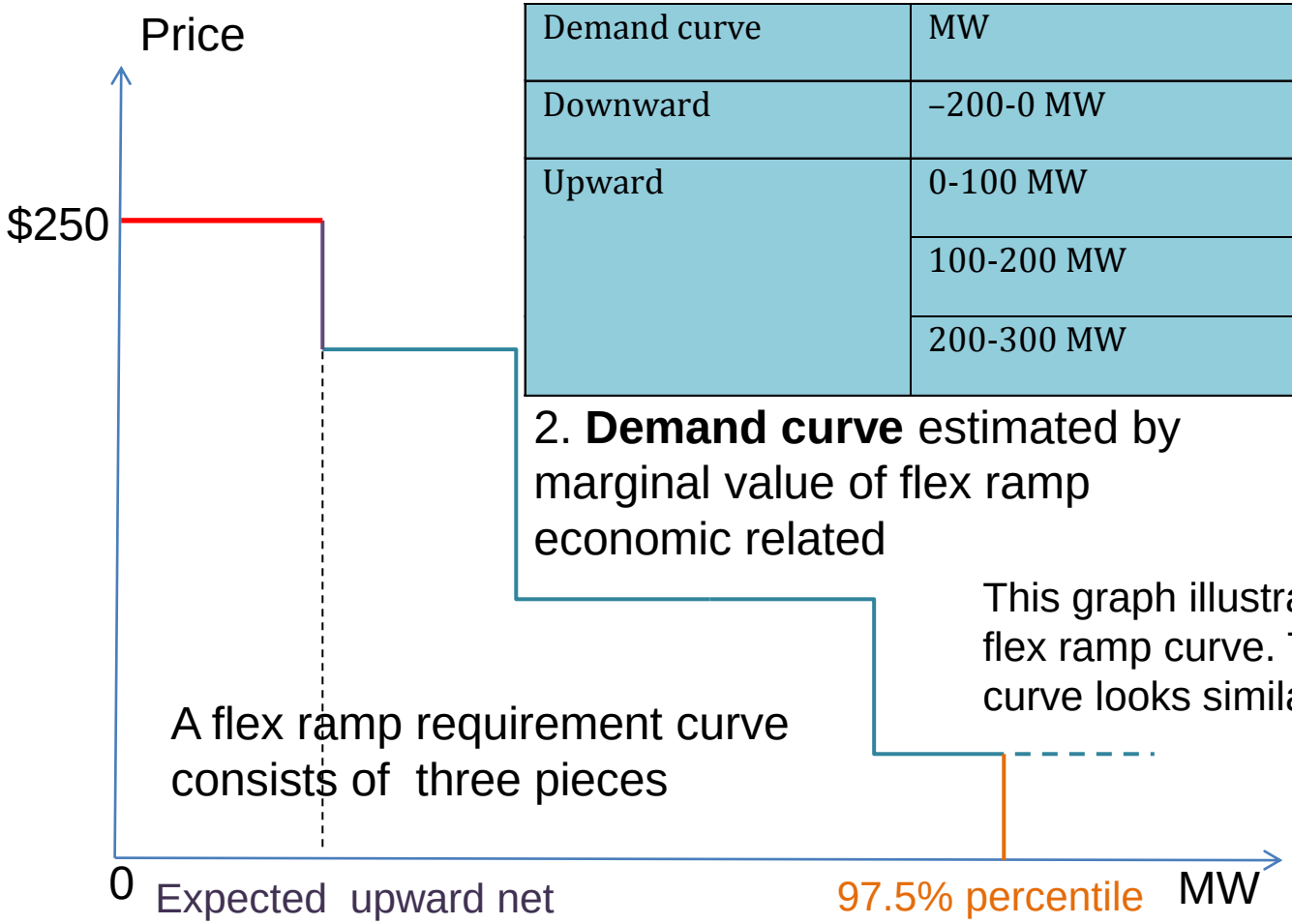
Power balance violation	Penalty
–200-0 MW	–$150
0-100 MW	$1000/MWh
100-200 MW	$3000/MWh
200-300 MW	$5000/MWh
300-400 MW	$6500/MWh

Example: Flex Ramp Demand Curve Calculation Based on PBV

Upward	0 MW flex ramp	100 MW flex ramp	200 MW flex ramp	300 MW flex ramp
PBV category	Penalty cost0	Penalty cost100	Penalty cost200	Penalty cost300
0-100 MW	228.08	0	0	0
100-200 MW	1087.06	116.35	0	0
200-300 MW	1074.77	387.14	43.14	0
300-400 MW	6355.73	3483.27	1246.51	134.35
Sum cost	8745.65	3986.76	1289.65	134.35
Flex ramp value	N/A	47.59	26.97	11.55

Downward	0 MW flex ramp	100 MW flex ramp	200 MW flex ramp	300 MW flex ramp
PBV category	Penalty cost0	Penalty cost100	Penalty cost200	Penalty cost300
–200-0 MW	400.05	200.03	0	0
Flex ramp value	N/A	2.00	2.00	0

Example: Flex Ramp Requirement and Demand Curve



Demand curve	MW	Price
Downward	–200-0 MW	$2.00/MWh
Upward	0-100 MW	$47.59/MWh
	100-200 MW	$26.97/MWh
	200-300 MW	$11.55/MWh

2. **Demand curve** estimated by marginal value of flex ramp economic related

This graph illustrates the upward flex ramp curve. The downward curve looks similarly.

A flex ramp requirement curve consists of three pieces

1. **Minimum requirement** reliability related

3. **Maximum requirement** statistical limit

Example: IFM input

Gen	Online	En bid	FRP bid	Reg up bid	Ramp rate	Pmin	Pmax
G1	6:00–10:00	25	0	N/A	100	0	500
G2	6:00–10:00	30	0	N/A	10	0	500
G3	6:00–10:00	36	12	10	60	0	500

Assume the following net system demand and flex ramp requirements are going to be met by these three generators.

Interval	Net system demand	Lower limit	Upper limit	FRU max requirement	FRD max requirement
7:00–8:00	450	n/a	n/a	170	0
8:00–9:00	1000	900	2490	170	0

Upward flex ramp demand price $20.

Assume minimum FRU requirement is 50 MW per 5 minutes based on DA forecasted net system demand.

Assume net system movement 97.5% percentile is 170 MW per 5 minutes.

Example: DA solution

	7:00–8:00	
Gen	En	FRU
G1	450	4.17
G2	0	41.67
G3	0	41.67
Price	$26.67	$20

min requirement 50 MW <=

FRU procurement 87.5 MW <=

max requirement 170 MW

$20 set by demand curve

Energy price $26.67 set by G1. G1 can provide 1 extra MW of energy with cost $20, and reduce its FRU award by 1/12 MW. This will cause FRU demand reduced by 1/12 MW . So the total incremental cost is 20 – 0*1/12 + 20*1/12=26.67.

Energy and FRU are competing for capacity. The demand curve helps the optimization to decide whether the capacity should be used as energy or FRU based on the FRU marginal price. If the FRU max requirement is a hard constraint, the optimization would have produced extreme market prices.

Example: Combined IFM and RUC Input

With IFM and RUC being combined into a single optimization, they share

- the same unit commitment decisions
- the same flex ramp and ancillary service awards.

IFM energy schedule including virtuals is based on bid-in demand, RUC capacity is based on load forecast. RUC capacity can be different from IFM energy schedule.

Interval	Net system demand	RUC Net system demand	FRU max requirement	FRD max requirement
7:00–8:00	450	750	170	0
8:00–9:00	1050	1350	170	0

Minimum requirement (1350 – 750)/12=50 MW.

Assume RUC bids are zero.

Upward flex ramp demand price $20.

Example: Combined IFM and RUC Solution

	7:00–8:00		
Gen	En	FRU	RUC
G1	450	4.17	450
G2	0	41.67	0
G3	0	16.67	300
Price	$25.83	$20	$0.83

In order to meet RUC requirement, G3 provides 300 MW RUC schedule.

This reduces G3's FRU to 16.67 MW.

RUC price $0.83 set by G3 and flex ramp demand.

G3 can provide 1 more MW of RUC capacity and reduce 1/12 MW of FRU.

This will also reduce FRU demand by 1/12 MW. The incremental cost is FRU penalty cost 1/12*20 – 1/12*G3's regulation bid $10 =$0.83. Note that regulation participated as flex ramp here.

$20 set by demand curve

G1 can provide 1 MW of energy and reduce 1/12 MW of FRU award. G3 can make up the 1/12 MW of FRU and reduce 1 MW RUC award. The incremental cost is $25 – 0*1/12+10*1/12=25.83. They set the energy LMP.

Example: RTUC input

Gen	Online	En bid	FRP bid	Reg up bid	Reg up capacity	En 6:47	Ramp rate	Pmin	Pmax
G1	6:00–10:00	25	0	N/A	N/A	400	100	0	500
G2	6:00–10:00	30	0	N/A	N/A	0	10	0	500
G3	6:00–10:00	36	12	10	200	0	60	0	500
G4	7:15–9:00	50	0	N/A	N/A	0	100	0	500

The bid applies to incremental award from DA FRP award. DA FRP award will be assigned zero cost. For example, G1's DA FRU award is 4.17 MW. In RTUC, 4.17 MW of G1's FRU will be assigned zero cost.

Interval	Net system demand	Lower limit	Upper limit	FRU max requirement	FRD max requirement
7:00–7:15	501	n/a	n/a	170	0
7:15–7:30	801	651	1011	170	0

Upward flex ramp demand price $20.

Example: RTUC Solution

	7:00–7:15		7:15–7:30	
Gen	En	FRU	En	FRU
G1	500	0	500	0
G2	1	50	151	50
G3	0	120	150	300
G4	0	0	0	500
Price	$30	$10	$36	$0

LMP set by G2.

Set by G3's regulation bid as a result of regulation participating as flex ramp.

With regulation participating as flex ramp, if a resource is bidding flex ramp higher than regulation, the optimization will be awarded regulation based on regulation bid, but use the capacity as flex ramp. The resource will receive a flex ramp price, which is consistent with the regulation bid, but may not be consistent with the flex ramp bid.

Example: RTD1 Input

Gen	Online	En bid	FRP bid	Reg up bid	Reg up capacity	En 6:47	Ramp rate	Pmin	Pmax
G1	6:00–10:00	25	0	N/A	N/A	400	100	0	500
G2	6:00–10:00	30	0	N/A	N/A	0	10	0	500
G3	6:00–10:00	36	12	10	200	0	60	0	500
G4	7:15–9:00	50	0	N/A	N/A	0	100	0	500

The bid applies to incremental award from DA FRP award. DA FRP award will be assigned zero cost. For example, G1's DA FRU award is 4.17 MW. In RTD, 4.17 MW of G1's FRU will be assigned zero cost.

Interval	Net system demand	Lower limit	Upper limit	FRU requirement	FRD requirement
7:00–7:05	400	n/a	n/a	170	0
7:05–7:10	500	450	570	240	0
7:10–7:15	600	550	740	310	0

Upward flex ramp demand price $20.

Example: RTD1 Solution

	7:00–7:05		7:05–7:10		7:10–7:15	
Gen	En	FRU	En	FRU	En	FRU
G1	302	198	352	148	402	98
G2	98	50	148	50	198	50
G3	0	0	0	42	18	162
G4	0	0	0	0	0	0
Price	$25	$0	$30	$5	$35	$10

G3 has DA FRU award 41.67 MW. In RTD, 41.67 MW of G3's FRU will be assigned zero cost.

G3' RTD1 FRU award 0 MW is less than its day-ahead award 41.67 MW without energy dispatch. In this case, the FRU price for RTD1 should be zero. As a result, G3 keeps its full day-ahead payment without any real-time payback assuming it exactly follows instruction.

Example: RTD2 Input

Gen	Online	En bid	FRP bid	Reg up bid	Reg up capacity	En 6:52	Ramp rate	Pmin	Pmax
G1	6:00–10:00	25	0	N/A	N/A	300	100	0	400
G2	6:00–10:00	30	0	N/A	N/A	100	10	0	500
G3	6:00–10:00	36	12	10	200	0	60	0	500
G4	7:15–9:00	50	0	N/A	N/A	0	100	0	500

Interval	Net system demand	Lower limit	Upper limit	FRU requirement	FRD requirement
7:05–7:10	650	n/a	n/a	120	0
7:10–7:15	750	600	770	190	0
7:15–7:20	850	700	940	260	0

Flex ramp demand price $20.

Lower limit and upper limit updated.

Example: RTD2 Solution

	7:05–7:10		7:10–7:15		7:15–7:20	
Gen	En	FRU	En	FRU	En	FRU
G1	500	0	500	0	500	0
G2	150	50	200	50	250	50
G3	5	70	50	140	100	0
G4	0	0	0	0	0	500
Price	$36	$10	$36	$10	$36	$0

In interval 7:05–7:10,G1 is fully dispatched for energy. It has to buy back its day-ahead FRU award at RTD price $10. The FRU $10 buy-back price is covered by the energy profit $11 ($36 – $25), so the energy dispatch and RTD FRU award yields $1/MWh net profit for G1. Generally, bidding $0 real-time FRP cost for day-ahead award will yield non-negative overall profit for a resource in real-time.

Example: Settlement for G1

G1	Schedule (MW)		Price ($/MWh)		IIE/UIE (MW)		settlement ($)		
Energy	7:00-7:05	7:05-7:10	7:00-7:05	7:05-7:10	7:00-7:05	7:05-7:10	7:00-7:05	7:05-7:10	Total
IFM	450.00	450.00	25.83	25.83			968.63	968.63	1937.25
RTD	302.00	500.00	25.00	36.00	-148.00	50.00	-308.33	150.00	-158.33
Meter	420.00	420.00	27.78	27.78	118.00	-80.00	273.15	-185.19	87.96
Total			weighted average price based on absolute IIE						1866.88

IIE = RTD energy – IFM energy Delta FRU = RTD FRU – IFM FRU

UIE = meter – RTD energy Unavailable FRU = available FRU based on meter – RTD FRU

G1	Schedule (MW)		Price ($/MWh)		D./U. FRU (MW)		settlement ($)		
FRU	7:00-7:05	7:05-7:10	7:00-7:05	7:05-7:10	7:00-7:05	7:05-7:10	7:00-7:05	7:05-7:10	Total
IFM	4.17	4.17	20.00	20.00			6.95	6.95	13.90
RTD	198.00	0.00	0.00	10.00	193.83	-4.17	0.00	-3.48	-3.48
Meter	80.00	80.00	0.21	0.21	-118.00	80.00	-2.07	1.40	-0.67
Total			weighted average price based on absolute delta FRU						9.76

PIRP Decremental Bidding

- On an hourly basis, PIRP resource submits:
  - Real-time self-schedule equal to 3rd party forecast
  - Maximum MW curtailment
  - Ramp rate
  - Energy bid price willing to be decremented
  - Flexible ramping down bid price
- The ISO will use the ISO 15 minute forecast for RTUC FRP headroom and to assess availability for decremental dispatch
- If resource is dispatched or awarded FRD, the 10 minute settlement interval is not included in monthly netting

DEC Bidding and FRD Example

Not dispatched or awarded FRD beyond maximum curtailment

Max Curtailment (MW)	60.0
Ramp Rate (MW/Min)	6
Bid Price	$ (100)
Maximum FRD Capacity (MW)	30.0

	Hour 1													
PIRP RT Self-Schedule (MW)	120.0												120.0	MWh
	RTUC 1			RTUC 2			RTUC 3			RTUC 4				
RTUC Expected Output (MW)	50.0			80.0			120.0			150.0			100.0	MWh
	RTD 1	RTD 2	RTD 3	RTD 4	RTD 5	RTD 6	RTD 7	RTD 8	RTD 9	RTD 10	RTD 11	RTD 12		
RTD Expected Output (MW)	50.0	50.0	50.0	80.0	80.0	80.0	120.0	120.0	120.0	150.0	150.0	150.0		
Bid Price	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)	$ (100)		
LMP	$ (150)	$ (50)	$ (50)	$ (50)	$ (150)	$ (90)	$ (150)	$ (90)	$ (150)	$ (150)	$ (50)	$ (75)		
FRD Award (MW)	0.0	0.0	0.0	20.0	0.0	20.0	30.0	30.0	30.0	30.0	30.0	30.0	18.3	MWh
Dispatch (MW)	120.0	120.0	120.0	120.0	60.0	120.0	90.0	120.0	90.0	120.0	120.0	120.0	110.0	MWh

Settlement	Int 1	Int 2	Int 3	Int 4	Int 5	Int 6		
Meter (MWh)	7.0	15.0	20.0	15.0	21.0	36.3	114.3	MWh
IIE (MWh)	20.0	20.0	15.0	17.5	17.5	20.0	110.0	MWh
UIE (MWh)	-13.0	-5.0	5.0	-2.5	3.5	16.3	4.3	MWh
PIRP Monthly Netting Settlement	Yes	No	No	No	No	No		

FRD Award Capacity Limited

Resource is dispatched or awarded FRD
UIE not eligible for monthly netting

15 Minute Expected Energy for Variable Energy Resources for use in Supply Category Cost Allocation

- In Master File, a variable energy resource can select:
  1. Hourly PIRP self schedule (No 15 minute update)
  2. ISO 15 minute forecast
  3. Resource submitted 15 minute forecast

- To address gaming concerns with resource submitted forecast, ISO will analyze forecasts every six months and provide to DMM
  - If resource submitted forecast systematically avoids cost allocation, this may be referred to FERC

15 minute Wind Forecast made 30 minutes prior

- Data from January 1, 2011 through May 31, 2012
- % Deviations = (Forecast - Actual) / Forecast
  - If Forecast > Actual, FRU allocation
  - If Actual > Forecast, FRD allocation
- Missing data excluded

Flexible Ramping Up (Forecast > Actual)

Wind 0:15 to 12:00

	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00
Average	11.6%	10.4%	11.4%	10.9%	10.2%	11.3%	10.8%	11.1%	12.3%	11.0%	10.9%	11.3%	11.4%	11.0%	10.7%	12.0%
Count Total	258	213	216	251	261	255	257	260	257	277	264	258	270	294	287	281
Count < 3%	71	65	58	66	81	67	80	78	73	89	76	78	75	88	82	83
Max	83.4%	85.4%	85.4%	84.0%	80.4%	87.5%	88.0%	85.9%	86.4%	88.7%	88.5%	89.2%	89.9%	92.1%	88.5%	94.5%
Min	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
SDev	13.9%	13.3%	13.1%	13.3%	12.4%	12.9%	12.9%	13.4%	14.6%	14.8%	14.1%	15.2%	15.1%	14.2%	14.1%	15.9%

	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00
Average	13.5%	11.9%	11.7%	13.7%	13.0%	12.8%	13.5%	13.6%	13.9%	12.8%	12.3%	13.8%	14.2%	13.8%	12.7%	13.2%
Count Total	278	286	279	268	267	243	256	277	269	287	284	274	269	259	273	268
Count < 3%	60	78	69	65	64	48	52	61	59	65	61	55	51	44	57	47
Max	96.4%	93.9%	93.0%	94.6%	96.6%	94.9%	93.5%	93.1%	94.1%	93.6%	93.3%	94.2%	92.8%	91.1%	89.0%	91.5%
Min	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.1%	0.1%
SDev	16.4%	14.2%	14.3%	17.3%	16.6%	15.2%	15.7%	16.8%	17.3%	15.2%	14.6%	16.2%	15.6%	13.8%	13.4%	13.6%

	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
Average	13.1%	14.0%	14.3%	15.6%	15.8%	15.4%	15.1%	15.1%	13.9%	14.7%	14.4%	14.8%	15.0%	13.7%	14.6%	15.5%
Count Total	282	272	284	285	274	299	286	278	288	282	273	273	278	264	248	255
Count < 3%	63	46	55	49	38	54	44	42	50	41	53	48	51	53	37	36
Max	91.1%	88.4%	87.9%	87.3%	90.1%	88.9%	86.7%	84.7%	83.9%	88.8%	91.0%	94.1%	93.2%	92.3%	85.6%	89.9%
Min	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.1%	0.1%
SDev	14.4%	14.3%	14.4%	15.4%	14.5%	14.5%	14.7%	15.1%	13.4%	14.2%	14.4%	14.5%	14.9%	13.8%	13.5%	14.6%

Flexible Ramping Up (Forecast > Actual)

Wind 12:00 to 24:00

	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00
Average	16.5%	16.5%	16.2%	16.8%	18.3%	18.2%	17.3%	16.4%	16.6%	17.2%	17.0%	16.3%	15.9%	17.4%	18.7%	17.1%
Count Total	254	269	279	257	260	269	263	257	242	247	245	243	226	233	230	267
Count < 3%	43	51	54	52	42	46	60	53	43	45	43	57	42	40	40	54
Max	100.0%	100.0%	100.0%	85.8%	100.0%	88.7%	98.2%	92.7%	85.3%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Min	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.2%	0.0%	0.0%	0.1%
SDev	16.5%	16.5%	16.9%	15.9%	17.1%	17.9%	17.9%	16.8%	16.5%	17.8%	17.8%	17.7%	17.6%	18.4%	19.2%	18.5%

	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	19:00	19:15	19:30	19:45	20:00
Average	16.4%	14.9%	14.8%	17.0%	16.7%	15.1%	13.7%	13.9%	13.3%	13.7%	13.6%	14.1%	13.6%	12.4%	12.3%	12.8%
Count Total	257	254	255	239	242	240	253	249	256	248	243	267	262	258	252	251
Count < 3%	59	60	59	47	56	53	55	62	70	62	59	67	68	65	63	66
Max	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Min	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%
SDev	18.4%	17.7%	17.3%	17.9%	17.8%	17.1%	16.3%	16.4%	16.7%	16.2%	16.0%	17.0%	16.5%	14.9%	14.9%	15.7%

	20:15	20:30	20:45	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45	23:00	23:15	23:30	23:45	0:00
Average	12.5%	12.9%	12.4%	11.6%	12.3%	11.0%	10.3%	10.9%	11.4%	11.1%	10.6%	9.7%	9.7%	11.2%	11.1%	10.1%
Count Total	243	257	231	216	232	254	244	226	203	228	238	246	252	246	244	258
Count < 3%	67	57	58	59	57	63	67	67	46	56	62	65	71	64	67	88
Max	100.0%	100.0%	100.0%	86.8%	87.1%	86.5%	86.1%	83.7%	82.9%	82.7%	81.9%	83.7%	83.2%	82.3%	81.8%	80.3%
Min	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%
SDev	15.8%	15.5%	15.1%	14.3%	14.2%	12.7%	12.5%	12.8%	13.0%	12.6%	12.4%	11.9%	12.1%	13.0%	12.9%	12.5%

Flexible Ramping Down (Actual > Forecast)

Wind 0:15 to 12:00

	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00
Average	13.4%	16.7%	22.0%	16.6%	15.3%	12.0%	11.4%	12.3%	16.4%	12.4%	12.4%	11.4%	12.1%	12.0%	13.7%	13.7%
Count Total	246	205	265	237	235	242	240	240	244	215	231	234	227	205	218	221
Count < 3%	76	43	71	69	61	71	79	68	74	77	81	73	65	60	61	74
Max	117.9%	172.5%	150.9%	111.8%	151.0%	151.6%	130.9%	94.7%	200.6%	105.6%	234.2%	110.6%	197.0%	133.7%	129.2%	122.0%
Min	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
SDev	20.3%	23.1%	30.7%	23.4%	23.6%	18.1%	17.9%	14.5%	26.2%	17.4%	21.9%	15.3%	18.7%	17.0%	21.0%	20.9%

	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00
Average	15.5%	13.5%	15.8%	14.3%	18.3%	13.7%	17.1%	15.2%	14.2%	13.6%	17.3%	13.2%	12.2%	13.4%	14.8%	18.5%
Count Total	226	218	228	236	240	230	248	224	237	217	223	230	238	247	232	236
Count < 3%	74	61	59	71	68	64	68	70	62	61	49	69	70	68	55	43
Max	128.4%	233.6%	203.5%	180.2%	521.7%	164.6%	151.4%	179.8%	129.5%	105.2%	196.1%	176.4%	209.0%	247.4%	290.6%	213.0%
Min	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
SDev	23.1%	22.9%	25.3%	23.5%	42.0%	22.0%	23.9%	26.0%	20.5%	18.2%	25.7%	20.5%	20.0%	22.9%	26.1%	26.9%

	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
Average	17.8%	15.1%	15.2%	14.4%	16.3%	19.1%	20.3%	25.9%	22.2%	21.8%	20.5%	20.0%	22.4%	20.5%	21.6%	28.9%
Count Total	225	234	224	221	232	204	220	227	218	225	234	232	228	243	264	251
Count < 3%	45	45	47	44	58	46	51	39	41	46	41	45	52	45	53	56
Max	217.6%	232.0%	270.7%	271.1%	314.3%	359.8%	384.1%	770.5%	406.3%	436.4%	436.7%	367.5%	472.0%	384.4%	559.6%	1879.2%
Min	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%
SDev	26.7%	21.1%	23.7%	22.9%	27.7%	32.7%	40.0%	66.5%	37.5%	41.1%	37.0%	32.8%	46.3%	40.8%	48.6%	126.0%

Flexible Ramping Down (Actual > Forecast)

Wind 12:00 to 24:00

	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00
Average	27.4%	21.7%	54.1%	20.9%	20.1%	18.3%	17.9%	21.7%	21.8%	20.5%	21.2%	23.3%	22.5%	30.4%	26.5%	26.2%
Count Total	255	241	232	250	251	241	246	249	264	261	265	259	281	276	277	244
Count < 3%	50	57	46	55	74	50	56	49	54	51	58	54	61	61	61	43
Max	1773.1%	1369.9%	5772.2%	446.2%	430.4%	440.2%	398.4%	365.1%	392.6%	383.6%	388.5%	758.7%	583.9%	1276.0%	1080.4%	888.6%
Min	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.2%	0.1%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%
SDev	117.5%	93.1%	404.0%	41.5%	38.9%	38.5%	40.1%	45.6%	43.2%	40.9%	39.7%	57.9%	47.2%	111.4%	84.3%	78.9%

	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	19:00	19:15	19:30	19:45	20:00
Average	24.6%	17.3%	19.1%	22.2%	22.6%	18.7%	17.3%	21.0%	27.4%	20.4%	19.0%	16.9%	17.9%	16.2%	18.3%	16.9%
Count Total	251	253	255	266	266	267	257	256	251	256	266	242	246	252	257	254
Count < 3%	57	56	55	74	54	63	69	73	57	74	73	58	63	67	68	75
Max	988.5%	488.3%	682.9%	1242.5%	973.7%	935.2%	570.3%	788.7%	898.9%	856.2%	621.7%	631.8%	574.7%	380.1%	547.6%	874.1%
Min	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
SDev	72.8%	36.9%	48.0%	83.0%	65.7%	60.8%	41.3%	56.6%	75.7%	63.7%	48.8%	45.3%	45.2%	33.4%	42.2%	61.0%

	20:15	20:30	20:45	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45	23:00	23:15	23:30	23:45	0:00
Average	17.7%	12.8%	14.7%	17.9%	19.6%	15.3%	15.2%	11.9%	14.3%	12.4%	26.1%	13.2%	17.3%	12.2%	11.6%	11.7%
Count Total	264	246	273	266	268	249	265	276	305	225	267	255	255	258	258	241
Count < 3%	77	73	81	69	81	63	77	86	82	72	44	71	59	91	77	68
Max	851.3%	477.4%	625.1%	685.5%	439.9%	456.8%	593.9%	206.5%	164.9%	180.3%	329.1%	168.8%	159.4%	140.7%	107.6%	99.4%
Min	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
SDev	60.3%	33.5%	43.3%	63.7%	37.7%	33.9%	42.6%	19.5%	22.3%	22.8%	37.1%	21.7%	26.0%	19.4%	17.3%	17.0%

15 minute Solar Forecast made 60 minutes prior

- Data from January 19, 2012 through September 10, 2012
- % Deviations = (Forecast - Actual) / Forecast
  - If Forecast > Actual, FRU allocation
  - If Actual > Forecast, FRD allocation
- Missing data excluded

Flexible Ramping Up (Forecast > Actual)

Solar 0:15 to 12:00

	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00
Average	45.1%	46.2%	46.4%	45.4%	45.8%	45.4%	45.3%	45.5%	44.9%	46.2%	45.3%	43.9%	44.8%	45.1%	45.0%	43.5%
Count Total	151	150	146	148	149	148	149	147	147	145	143	143	142	142	144	148
Count < 3%	5	5	4	3	2	4	3	1	4	3	2	2	2	0	1	6
Max	95.3%	93.6%	91.8%	91.9%	92.9%	92.3%	92.4%	92.0%	91.9%	90.9%	91.1%	90.5%	90.6%	90.7%	91.7%	92.3%
Min	0.4%	0.4%	1.7%	0.2%	0.8%	0.7%	0.3%	0.1%	0.0%	0.2%	0.6%	1.9%	2.6%	3.2%	1.9%	0.1%
SDev	26.2%	25.8%	25.4%	25.2%	25.4%	25.5%	25.7%	25.9%	26.0%	25.2%	25.0%	25.5%	25.3%	25.3%	25.7%	26.2%

	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00
Average	43.6%	43.3%	44.6%	44.5%	44.9%	44.0%	44.8%	32.0%	23.1%	23.4%	21.3%	9.8%	9.4%	10.2%	10.5%	9.6%
Count Total	148	149	148	148	146	149	145	147	121	122	126	186	185	154	153	134
Count < 3%	3	4	4	3	2	5	4	7	17	24	24	61	60	55	53	43
Max	94.2%	93.4%	95.1%	94.2%	92.8%	90.7%	90.7%	89.1%	90.1%	84.9%	86.7%	87.0%	82.8%	90.5%	89.3%	54.4%
Min	0.1%	0.2%	0.1%	0.9%	0.8%	0.1%	0.8%	0.6%	0.4%	0.6%	0.4%	0.0%	0.1%	0.2%	0.1%	0.4%
SDev	26.2%	26.4%	26.6%	26.2%	25.8%	26.2%	25.6%	24.9%	23.6%	24.2%	22.9%	15.2%	14.1%	13.9%	12.5%	9.8%

	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
Average	8.8%	8.4%	8.4%	8.0%	7.7%	7.0%	6.7%	6.8%	6.4%	6.2%	5.5%	5.1%	4.9%	4.6%	4.6%	4.5%
Count Total	126	129	122	121	118	116	109	103	100	101	99	105	104	107	109	115
Count < 3%	50	45	48	50	51	52	51	47	44	47	48	54	52	56	56	62
Max	56.0%	52.7%	36.9%	50.3%	67.5%	69.5%	61.9%	60.0%	55.2%	53.4%	49.2%	45.5%	43.3%	38.2%	34.8%	32.3%
Min	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%
SDev	10.2%	9.1%	8.9%	8.9%	9.2%	9.1%	8.3%	8.3%	7.8%	7.8%	7.0%	6.3%	6.1%	5.6%	5.3%	5.1%

Flexible Ramping Up (Forecast > Actual)

Solar 12:00 to 24:00

	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00
Average	4.0%	4.3%	4.4%	4.4%	4.6%	5.0%	5.3%	5.0%	5.6%	6.0%	6.1%	5.7%	6.0%	5.7%	5.8%	5.5%
Count Total	123	114	115	110	103	95	84	96	96	99	101	100	100	116	108	116
Count < 3%	71	61	62	58	54	45	39	48	41	42	42	43	38	52	48	57
Max	30.7%	31.1%	29.9%	25.7%	23.9%	25.3%	24.8%	24.5%	26.8%	31.3%	36.4%	38.5%	38.8%	35.4%	32.6%	29.0%
Min	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
SDev	4.7%	4.8%	5.0%	4.9%	5.1%	5.3%	5.2%	5.1%	5.5%	6.1%	6.6%	6.5%	6.4%	6.3%	6.3%	6.3%

	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	19:00	19:15	19:30	19:45	20:00
Average	6.1%	6.1%	6.1%	7.1%	7.4%	8.2%	8.8%	9.2%	9.1%	9.1%	9.6%	9.9%	11.3%	12.7%	12.6%	13.1%
Count Total	107	123	119	108	118	122	123	116	115	109	109	108	99	96	100	101
Count < 3%	48	61	62	51	56	55	52	53	57	54	49	46	33	32	32	28
Max	31.6%	34.8%	51.6%	63.7%	56.9%	51.2%	74.1%	80.1%	83.9%	84.5%	79.2%	83.6%	92.3%	92.5%	79.8%	85.6%
Min	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	0.1%	0.2%
SDev	6.9%	7.1%	7.8%	9.3%	9.3%	10.0%	11.8%	13.2%	13.7%	14.4%	14.0%	13.8%	15.4%	17.3%	16.7%	17.8%

	20:15	20:30	20:45	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45	23:00	23:15	23:30	23:45	0:00
Average	13.1%	14.0%	14.6%	20.1%	35.3%	33.6%	33.2%	29.3%	30.5%	31.2%	32.3%	31.5%	43.0%	47.2%	44.7%	50.9%
Count Total	101	100	106	107	106	107	112	118	110	108	107	111	122	136	140	136
Count < 3%	25	26	22	21	19	24	25	26	23	21	22	18	4	3	4	1
Max	80.4%	93.3%	93.6%	99.4%	99.7%	99.7%	100.0%	99.9%	99.8%	99.8%	99.4%	98.9%	99.1%	98.6%	96.9%	96.8%
Min	0.0%	0.2%	0.1%	0.1%	0.3%	0.3%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	1.0%	0.5%	0.1%	1.1%
SDev	16.0%	17.7%	18.1%	22.3%	34.7%	33.7%	34.8%	31.7%	31.7%	32.2%	32.2%	29.9%	26.9%	26.5%	25.3%	23.6%

Flexible Ramping Down (Actual > Forecast)

Solar 0:15 to 12:00

	0:15	0:30	0:45	1:00	1:15	1:30	1:45	2:00	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00
Average	197.9%	217.9%	202.8%	217.8%	226.2%	215.1%	213.0%	193.7%	199.4%	194.8%	190.6%	195.1%	189.7%	186.2%	191.5%	205.4%
Count Total	81	82	86	84	83	84	83	85	85	87	89	89	90	90	88	84
Count < 3%	1	1	2	0	0	2	2	4	6	4	5	5	3	4	3	0
Max	3271.9%	3431.1%	3426.4%	3743.9%	3800.9%	3740.3%	3825.2%	3834.5%	3896.8%	3533.7%	3706.3%	3797.1%	3918.2%	4029.7%	4038.5%	4556.3%
Min	0.5%	2.7%	0.5%	3.8%	3.4%	2.6%	0.5%	1.1%	1.4%	0.8%	0.6%	0.0%	0.1%	0.2%	0.5%	3.5%
SDev	408.8%	468.4%	428.4%	474.4%	474.6%	463.8%	471.4%	455.6%	463.7%	435.5%	449.5%	459.2%	466.6%	470.1%	475.0%	534.6%

	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00
Average	201.8%	198.9%	197.7%	166.5%	159.2%	168.9%	156.6%	54.3%	79.7%	71.4%	20.2%	7.5%	5.9%	7.7%	7.9%	7.5%
Count Total	84	83	84	84	86	83	87	85	111	110	106	46	47	78	79	98
Count < 3%	3	1	4	3	3	2	5	6	22	15	25	19	23	36	38	50
Max	4384.9%	4495.4%	4619.6%	1916.3%	1558.4%	1605.1%	1480.9%	617.6%	3694.2%	1971.5%	285.2%	64.2%	25.2%	145.3%	126.8%	114.5%
Min	0.5%	1.0%	0.8%	0.6%	0.1%	2.2%	0.1%	0.1%	0.0%	0.2%	0.0%	0.1%	0.1%	0.3%	0.1%	0.0%
SDev	517.8%	525.3%	538.3%	299.7%	277.3%	285.4%	268.4%	84.0%	362.2%	220.5%	35.0%	10.9%	6.7%	17.3%	15.7%	14.6%

	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
Average	9.2%	10.6%	10.9%	11.5%	10.9%	11.4%	10.7%	10.2%	9.8%	9.2%	8.2%	7.4%	6.7%	6.5%	6.0%	6.2%
Count Total	106	103	110	111	114	116	123	129	132	131	133	127	128	125	123	117
Count < 3%	43	37	40	42	44	45	48	52	53	51	53	57	60	60	64	56
Max	112.9%	94.8%	59.6%	92.6%	90.9%	103.8%	102.6%	99.0%	91.7%	80.9%	62.0%	44.6%	41.0%	43.3%	34.1%	37.8%
Min	0.0%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
SDev	14.7%	14.1%	13.7%	15.4%	14.4%	16.4%	16.7%	15.6%	14.5%	13.2%	10.2%	8.9%	7.9%	7.9%	7.4%	7.3%

Flexible Ramping Down (Actual > Forecast)

Solar 12:00 to 24:00

	12:15	12:30	12:45	13:00	13:15	13:30	13:45	14:00	14:15	14:30	14:45	15:00	15:15	15:30	15:45	16:00
Average	6.4%	6.2%	7.5%	7.8%	8.1%	8.2%	7.9%	8.7%	8.9%	9.3%	9.8%	10.4%	10.5%	11.9%	12.1%	13.5%
Count Total	109	118	117	122	129	137	148	136	136	133	131	132	132	116	124	116
Count < 3%	49	54	51	54	58	63	71	61	67	69	63	61	64	48	57	47
Max	33.8%	35.9%	49.5%	53.6%	53.7%	64.0%	61.0%	61.5%	62.2%	71.2%	73.9%	86.2%	90.8%	82.3%	84.0%	84.1%
Min	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
SDev	7.0%	7.2%	9.5%	10.2%	11.2%	11.9%	11.4%	12.4%	13.1%	13.7%	14.0%	15.0%	15.6%	16.7%	17.5%	19.0%

	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	19:00	19:15	19:30	19:45	20:00
Average	13.3%	17.3%	19.9%	18.3%	19.6%	21.7%	18.5%	16.9%	20.7%	22.1%	25.7%	32.5%	49.5%	615.8%	917.8%	210.0%
Count Total	125	109	113	124	114	110	109	116	117	123	123	124	133	136	132	131
Count < 3%	54	40	38	44	37	41	39	41	34	36	39	35	37	35	34	31
Max	136.0%	221.2%	335.2%	323.6%	263.6%	341.8%	267.2%	238.4%	364.3%	412.5%	300.8%	435.7%	1763.9%	75496.1%	########	12433.5%
Min	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	0.1%
SDev	20.9%	29.2%	41.1%	38.0%	36.9%	46.2%	32.8%	29.9%	45.2%	46.5%	46.3%	62.7%	170.9%	6475.3%	9675.3%	1242.9%

	20:15	20:30	20:45	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45	23:00	23:15	23:30	23:45	0:00
Average	979.8%	1359.0%	1770.6%	1468.2%	1228.8%	1400.8%	1459.5%	1553.3%	1147.7%	2373.6%	1891.2%	1164.5%	140.5%	186.5%	172.6%	151.8%
Count Total	131	132	126	125	126	125	120	114	122	124	125	121	110	96	92	96
Count < 3%	33	32	28	21	15	19	18	11	19	21	17	14	7	6	2	4
Max	55675.7%	78622.4%	76863.0%	43155.9%	35407.2%	45547.1%	55429.4%	58383.7%	44812.0%	########	########	59170.7%	2343.9%	2613.3%	2084.9%	1959.1%
Min	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.4%	0.2%	0.0%	0.0%	0.2%	0.1%	0.7%	0.2%	1.9%	0.3%
SDev	6089.6%	8780.2%	9888.7%	6022.5%	4338.7%	5222.5%	5863.3%	6317.5%	4826.4%	15214.1%	13049.1%	5800.4%	273.3%	367.0%	308.6%	285.9%

Movement (initial allocation) for supply category includes internal self-schedules

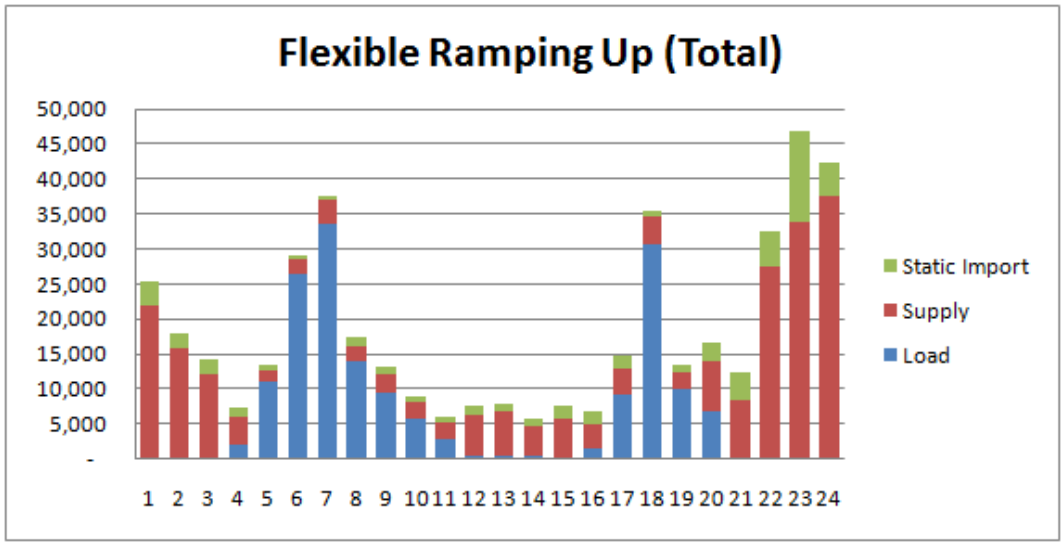
- Variable energy resource, then delta UIE
- If an internal resource is dispatched, then delta UIE
- If an internal resource has a self-schedule and has been dispatch above self-schedule, then delta UIE and delta self schedule
- If an internal resource has a self-schedule and has not been dispatched above self schedule, then delta “meter”

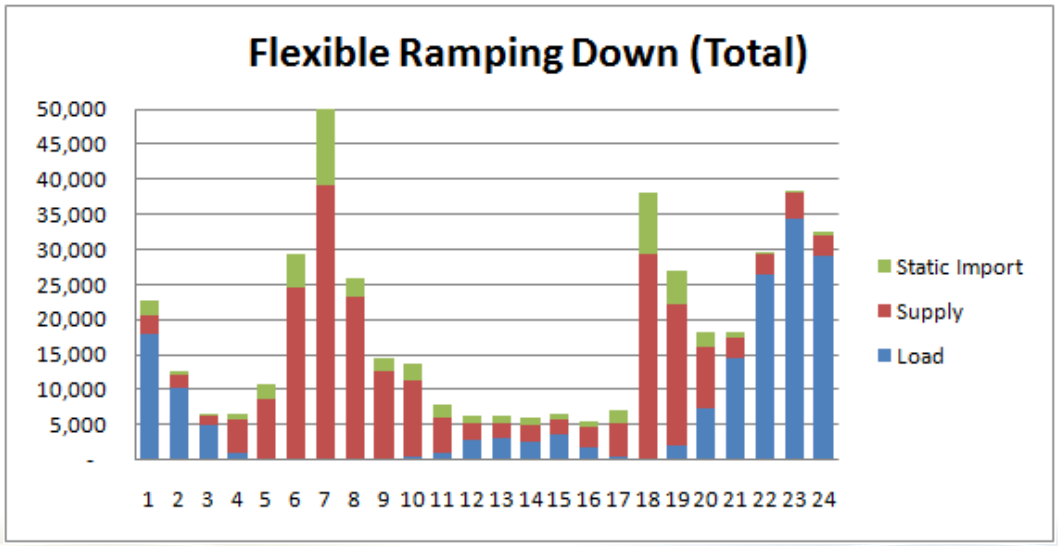
Common movement metric used to divide total costs in to three categories

			Metric	Meter
1	Load	Net Across LSEs	Change in 10 Min Observed Load	Hourly
2	Variable Energy Resource	Net Across all Supply	Change in 10 Min UIE	10 Minute
	Internal Generation			
	Dynamic Transfers			
	Internal Self Schedules		Change in 10 Min Ramp	
3	Fixed Ramp – Static Interties	Net Across all SCs 20 Minute Ramp Modeled	10 Min change in MWh deemed delivered	None

Note: Supply threshold not used in allocation to category

Split between categories





Uses data already posted.

Moves self-schedules to supply category.

No adjustment for self schedules with an incremental dispatch

Difficulty with using deltas to allocate within supply category

- Initial allocation to the supply category based on common movement metric
- Utilizing existing settlement charge codes within category greatly simplifies design for both ISO and market participants
- Can be argued that gross UIE provides greater clarity to incentivize behavior
  - Not allocated a cost for returning to schedule

Allocation within the supply category

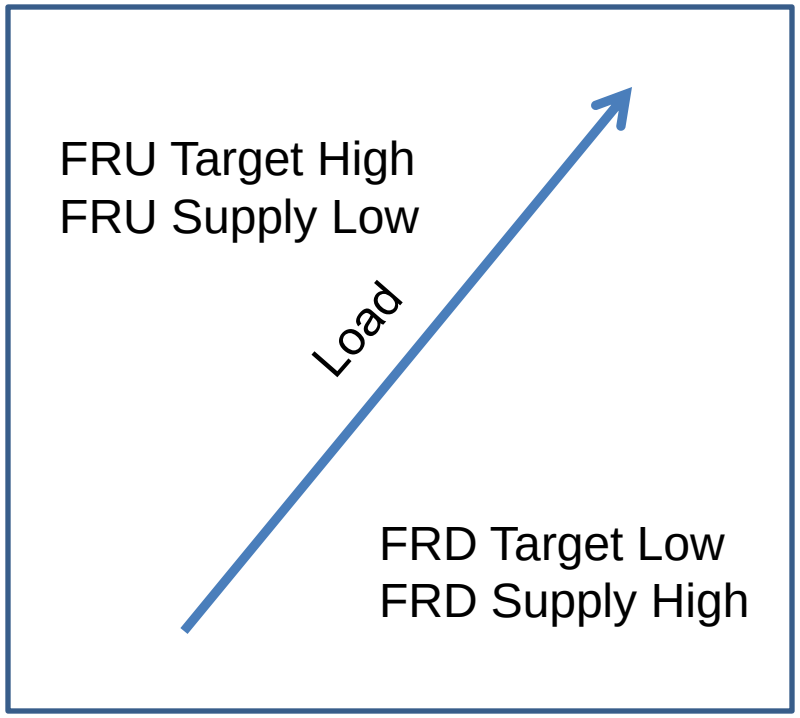
- VER, then gross deviation from 15 minute profile
- No self schedule, then gross UIE
- Self-schedule and dispatched in RTD, then gross UIE
- Self-schedule and not dispatched, then gross honored ramp
  - Standard Ramping Energy + Ramping Energy Deviation + Residual Imbalance Energy + UIE 1 + UIE 2
- Threshold applies to all above
  - Minimum of 3% of instruction or 0.83 MWh (5MW/6)

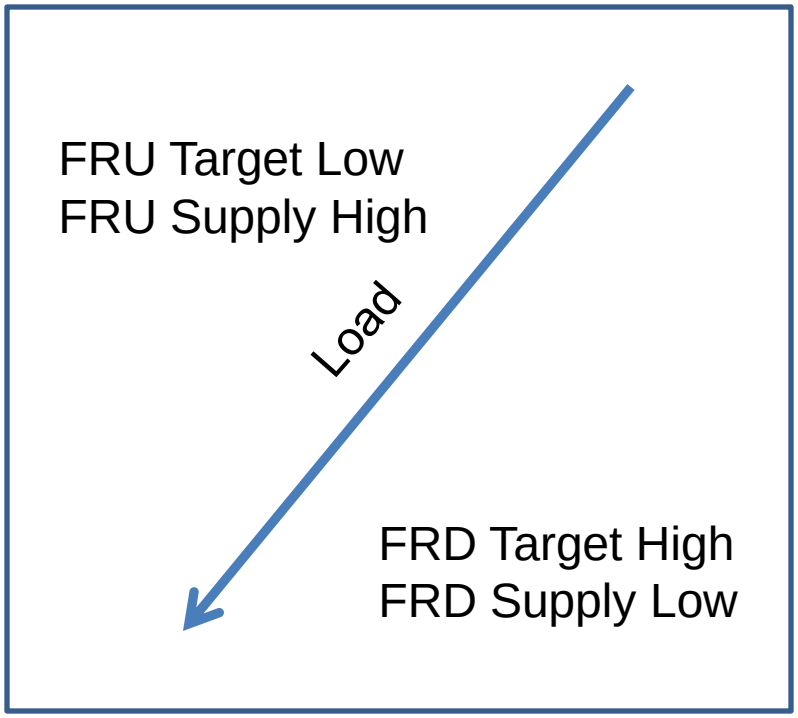
Allocation of each pie slice

		Baseline	Actual	Deviation	Allocation
1	Load	Day-Ahead Schedule	Metered Demand	UIE	Gross Deviation
2	Variable Energy Resource	15 Minute Expected Energy	10 Minute Meter	Baseline - Actual	Gross Deviation Outside Threshold
	Generation with Instructed Energy	Instruction	10 Minute Meter	UIE1 + UIE2	Gross UIE Outside Threshold
	Generation with Self Schedule	N/A	N/A	SRE + RED + RIE + UIE	Gross Ramp Outside Threshold
	Dynamic Transfers	Instruction	10 Minute Meter	UIE1 + UIE2	Gross UIE Outside Threshold
3	Fixed Ramp Interties & Self-Schedules	Ramp Modeled	Assumed Delivered	Net Movement	Gross by SC

No netting across settlement intervals.

Expectation of relative cost of flexible ramping up versus flexible ramping down





A resource following load should see lower relative cost allocation if deviation/movement in direction of load pull

Next Steps

Item	Date
Stakeholder Technical Workshop	September 18, 2012
Stakeholder Comments Due	September 24, 2012
Post 2nd Revised Draft Final Proposal	September 26, 2012
Stakeholder Call	October 2, 2012
Stakeholder Comments Due	October 9, 2012
Board of Governors Meeting	November 1-2, 2012

Submit written comments to FRP@caiso.com

Questions

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