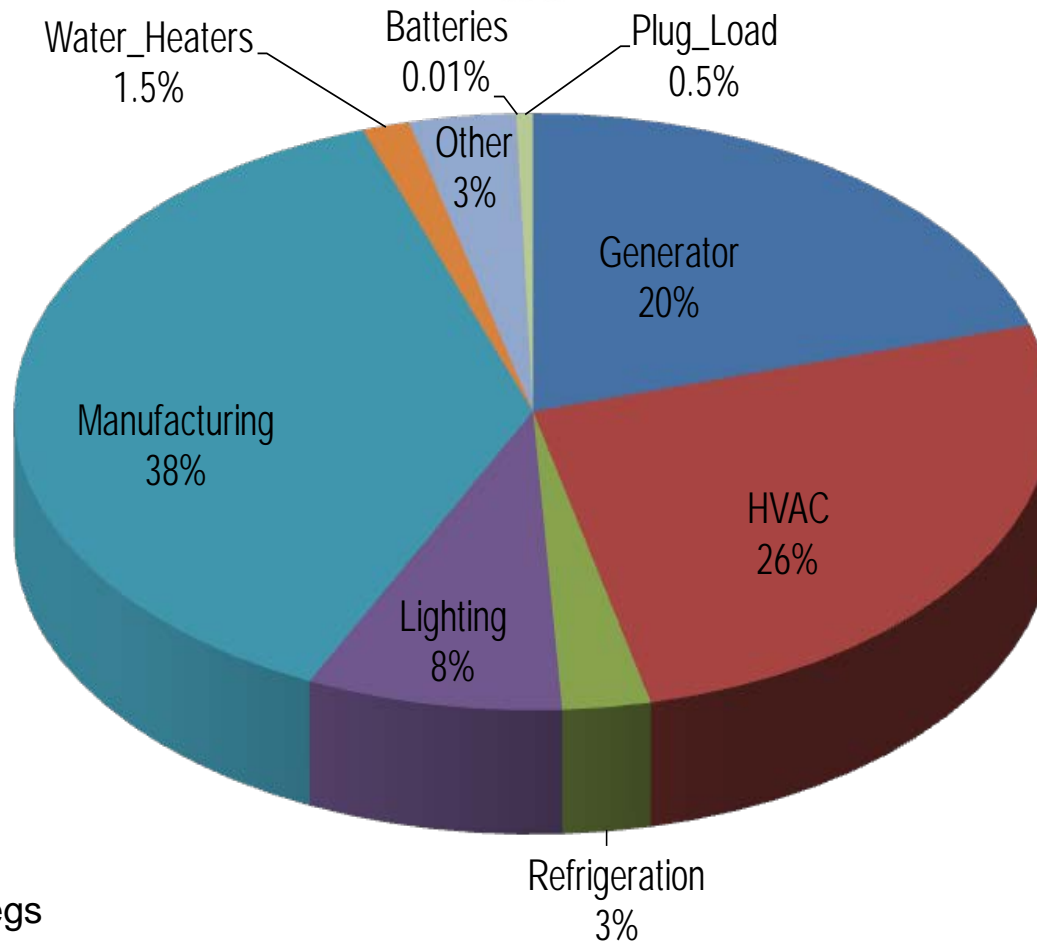


Demand Response in PJM

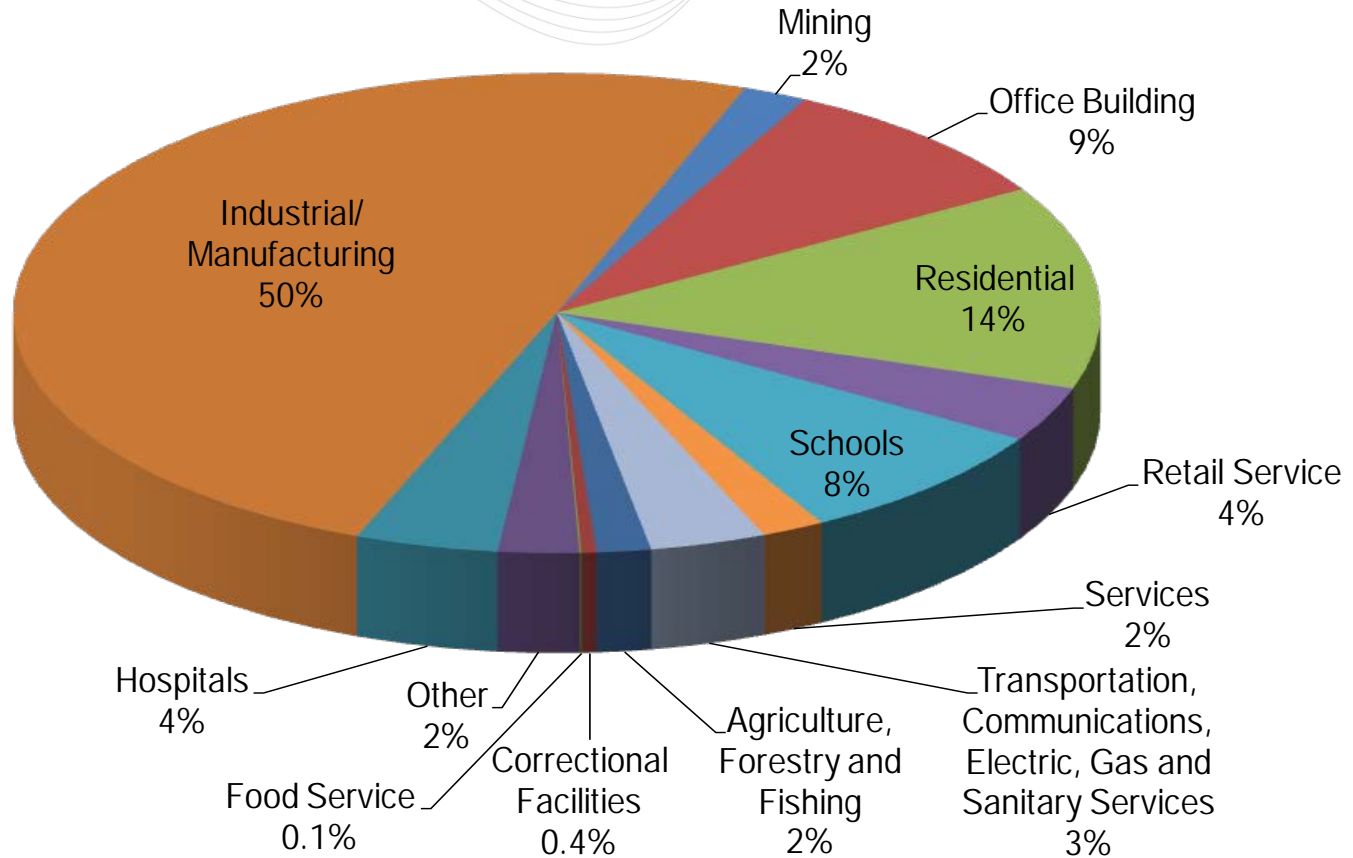
February 24, 2014

- Demand Response Overview
- Emergency Operations
- Measurement & Verification
- Policy Issues

- Demand response (DR)
 - reduction in electricity consumption based on PJM instructions & prices
 - Behind the meter
 - No power injections
 - PJM indifferent to method of load reduction

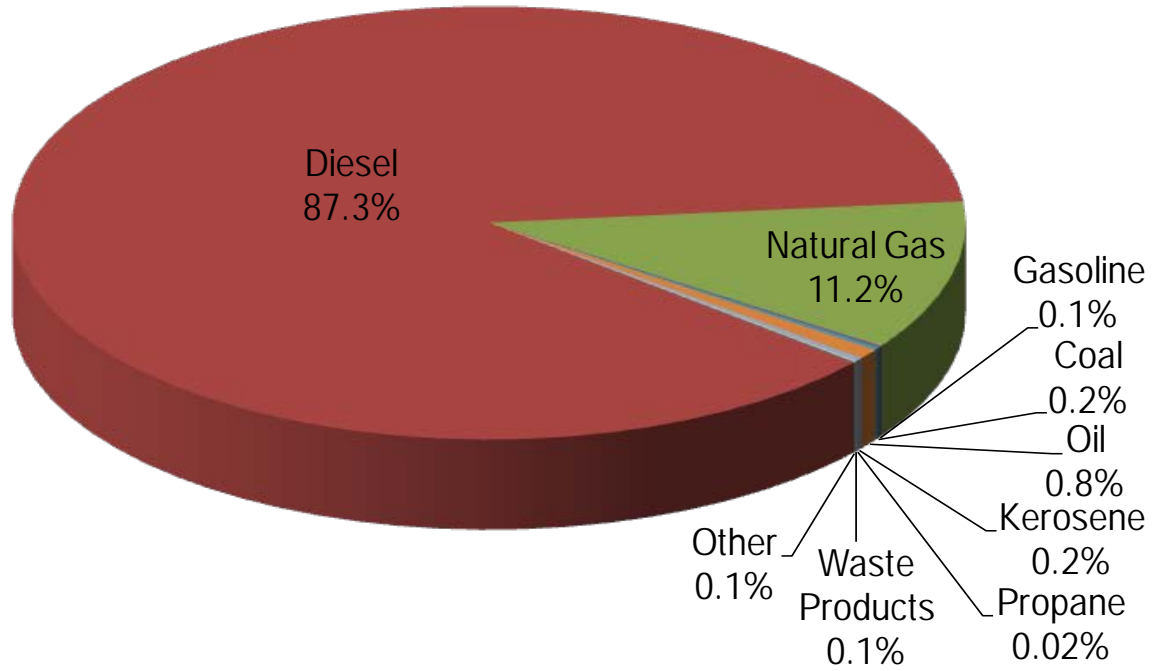


2013-14 Emergency Regs



2013-14 Emergency Regs

Fuel mix for behind the meter generation

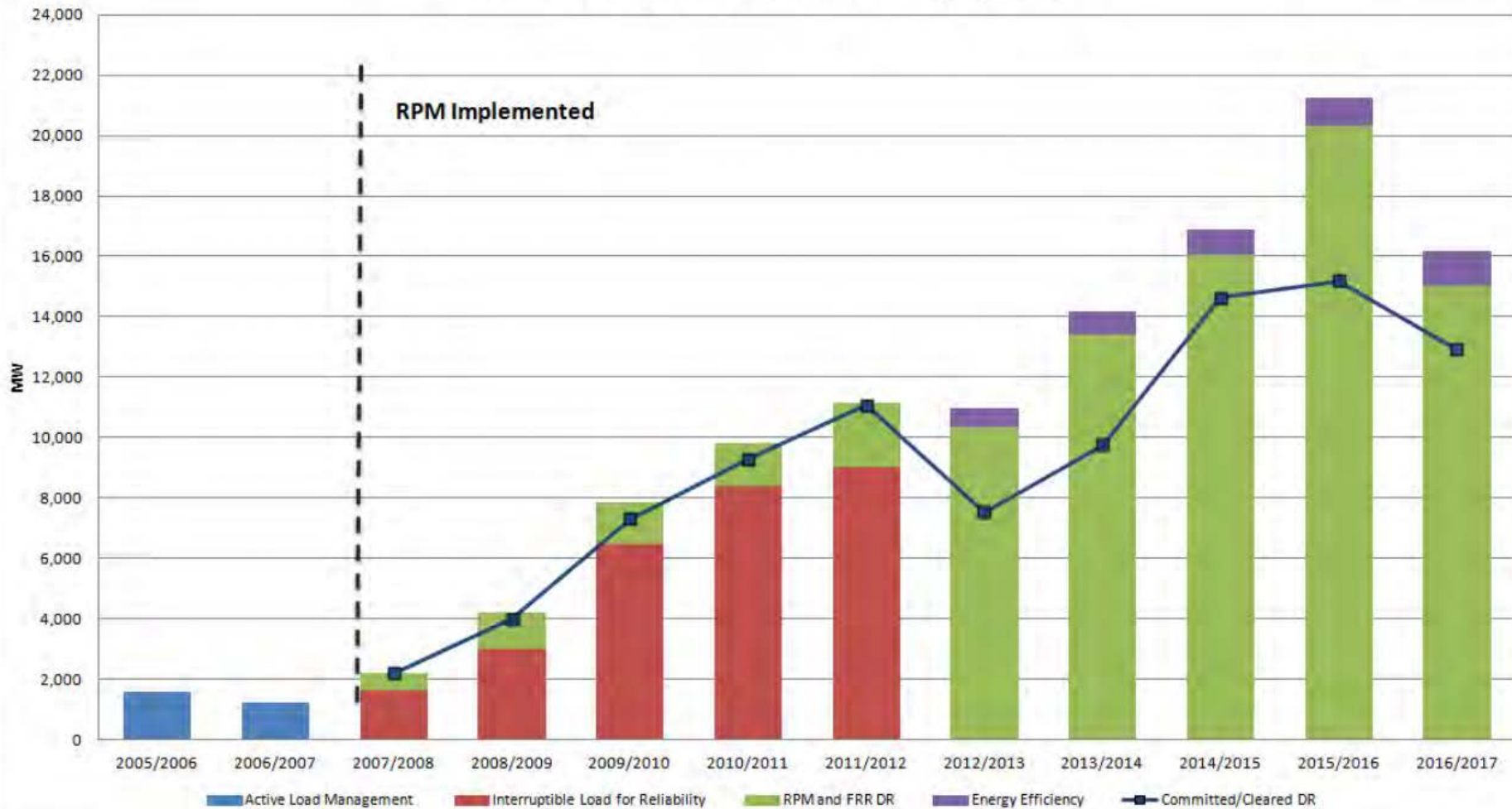


2013-14 Emergency Regs

- **Emergency**
 - Capacity (reliability pricing model - RPM)
- **Economic**
 - Energy
 - Day Ahead (DA)
 - Real Time (RT)
 - Ancillary Services
 - Regulation (Reg)
 - Synchronized Reserves (SR)
 - Day Ahead Scheduling Reserves (DASR)

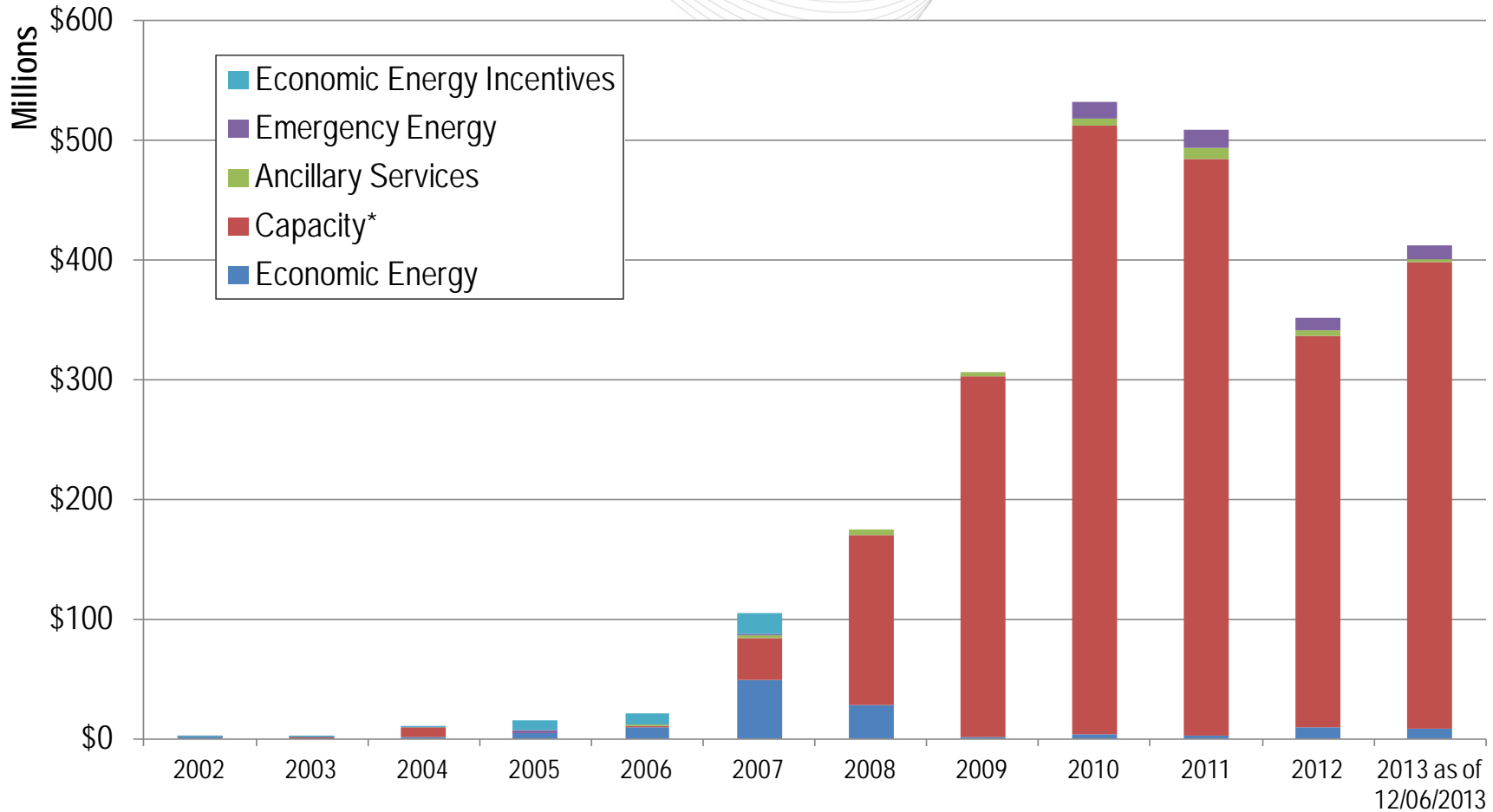
- DR as Capacity
 - A commitment to reduce load during PJM emergency under the capped energy price
 - Must reduce load during emergency event (pre-emergency in future)
 - 3 year forward auction
 - Capacity revenues paid to committed resource whether or not energy is produced by resource
 - Daily product

Demand Side Participation in Capacity Market



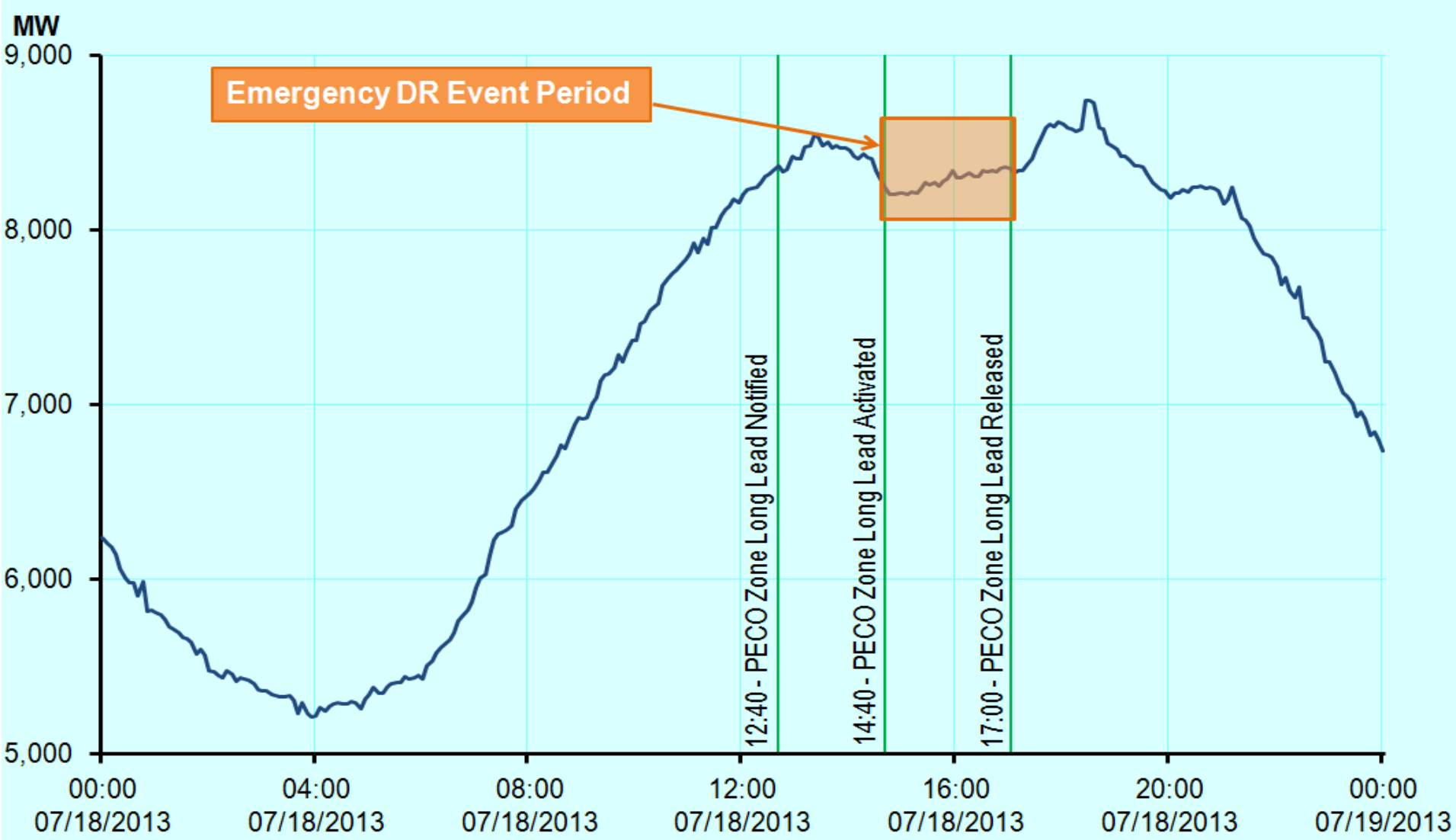
- DR in energy market
 - Day Ahead (DA) market
 - Real Time (RT) market
 - Reduce load when cleared in DA/RT market
 - Response to LMP
 - At PJM direction
 - Economic
 - Offer curve
 - Only cleared if makes economic sense
 - Only paid if $LMP > \text{Net benefits test (NBT)}$

- Day ahead scheduling reserves
 - Reduce load within 30 minutes if dispatched by PJM
- Synchronized Reserves
 - Reduce load within 10 minutes if dispatched
- Regulation
 - Reg A signal
 - Reg D signal



Market	Available DR (MW)	Available DR as % of total	Total Locations
Emergency	9000	5%	15,800
Energy	2300	1.5%	1500
Synch Reserves (MAD)	375	28%	161
Regulation	6	1%	71

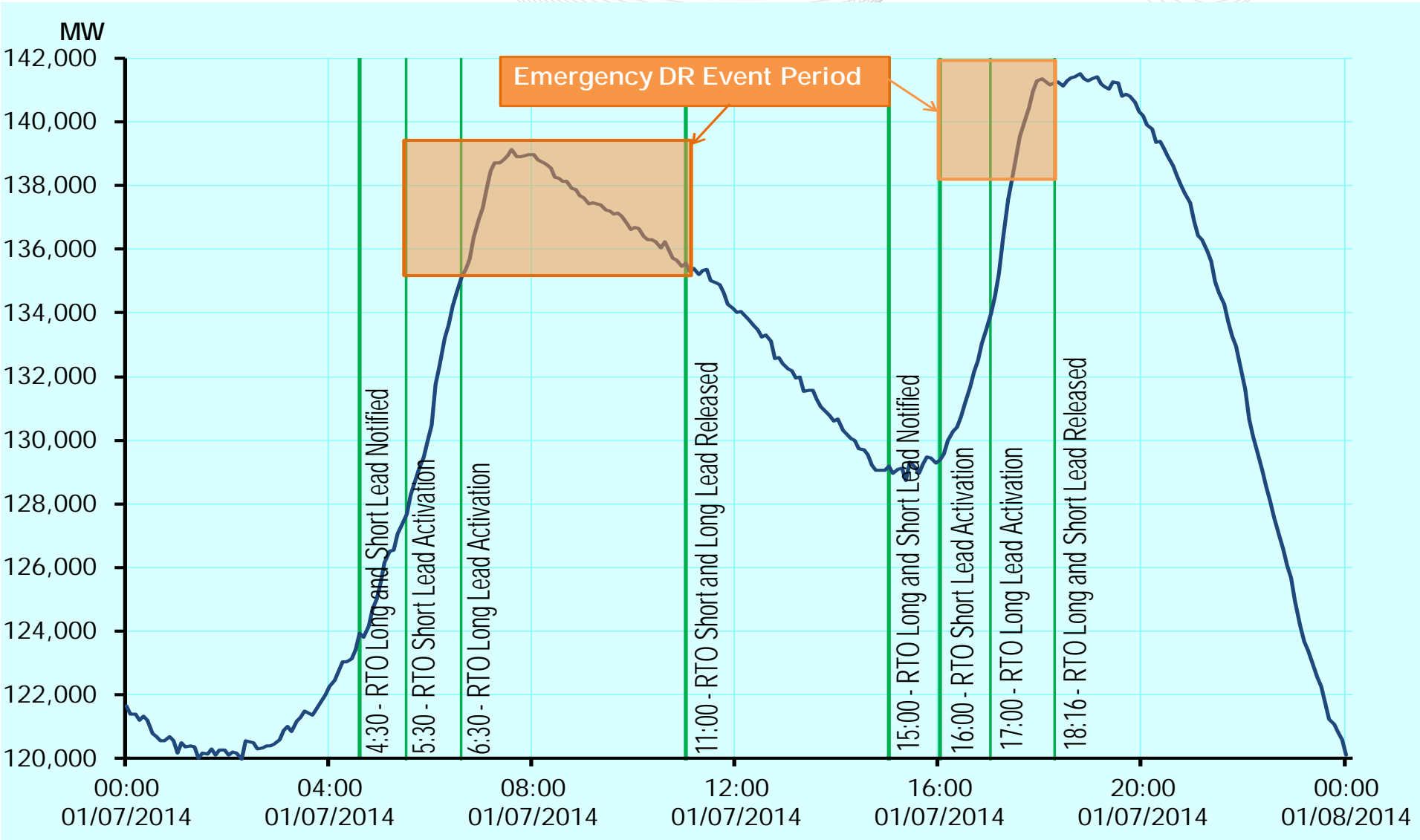
- Demand Response Overview
- **Emergency Operations**
- Measurement & Verification
- Policy Issues



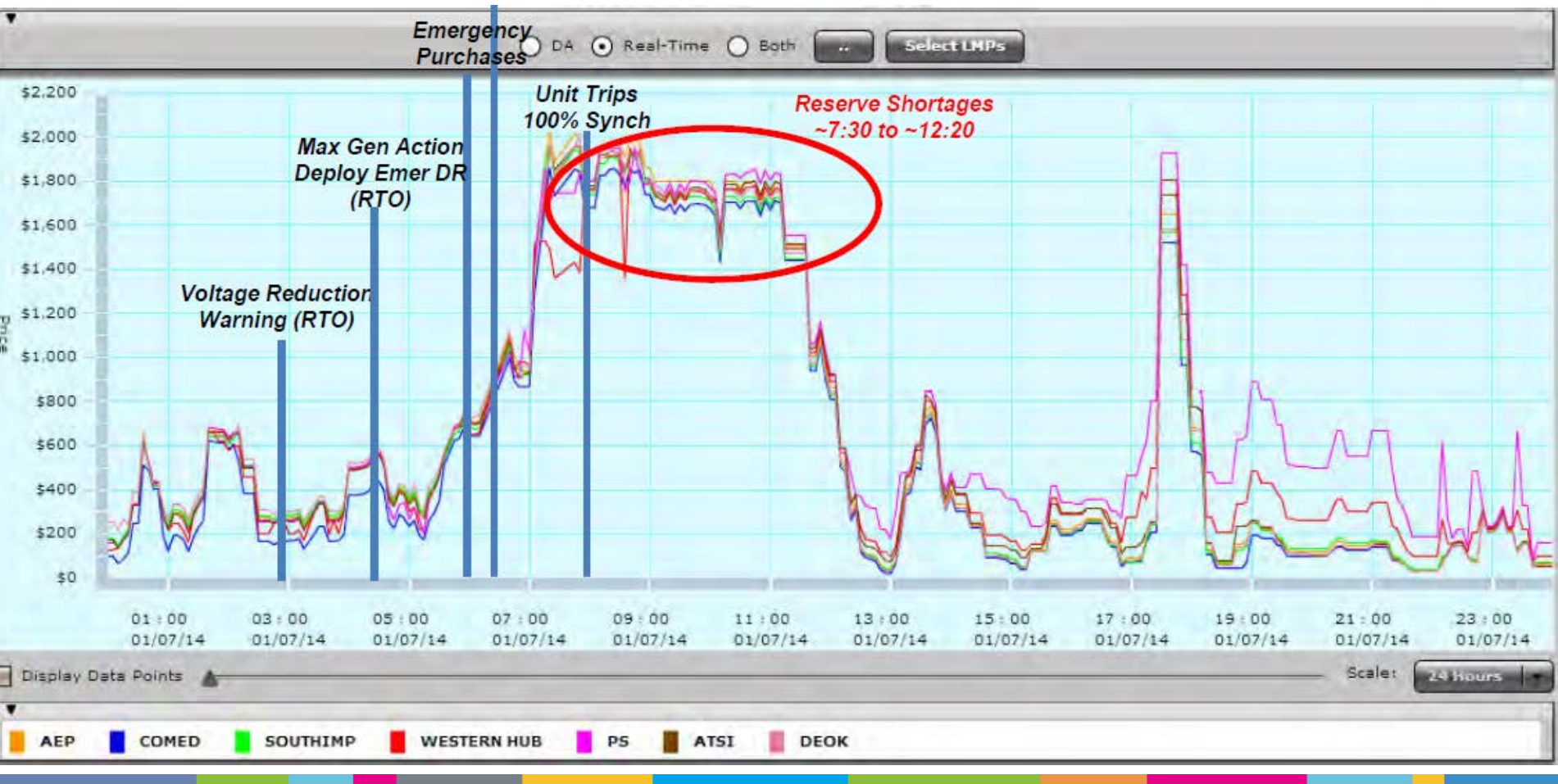
- Cold weather emergency issued – call for conservation
- Valley load forecast – 116,000 MW
actual – 120,000 MW
- Morning peak – forecast ~140,000 MW
- Jan 6 – emergency DR, voltage reduction, large unit trips

- 02:51 – voltage reduction warning for RTO
- 04:30 – deploy all emergency DR for RTO
(effective 05:30, 06:30)
 - Max gen action for RTO
- 06:00 – emergency purchases from NYISO and MISO begin to flow
- 06:21 – load all max emergency generation
- 06:27 – 100% SR for low ACE
- 08:18 – unit trips; 100% SR

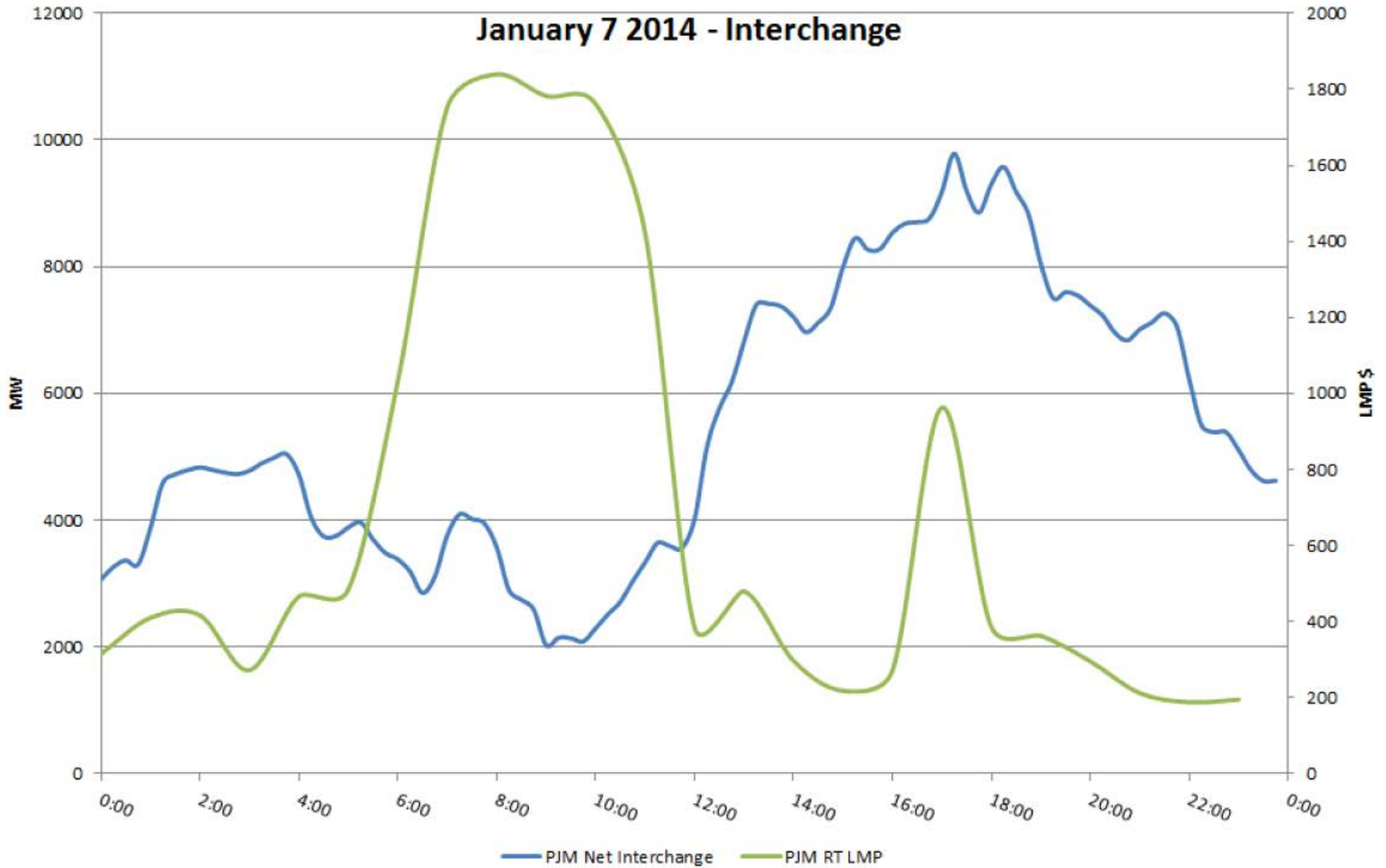
- 15:00 – max emergency gen action and deploy emergency DR across RTO (effective 16:00, 17:00)
- Unanticipated interchange sinking to PJM
 - 8,000 – 10,000 MW – mostly MISO
- 18:15 – cancelled emergency DR



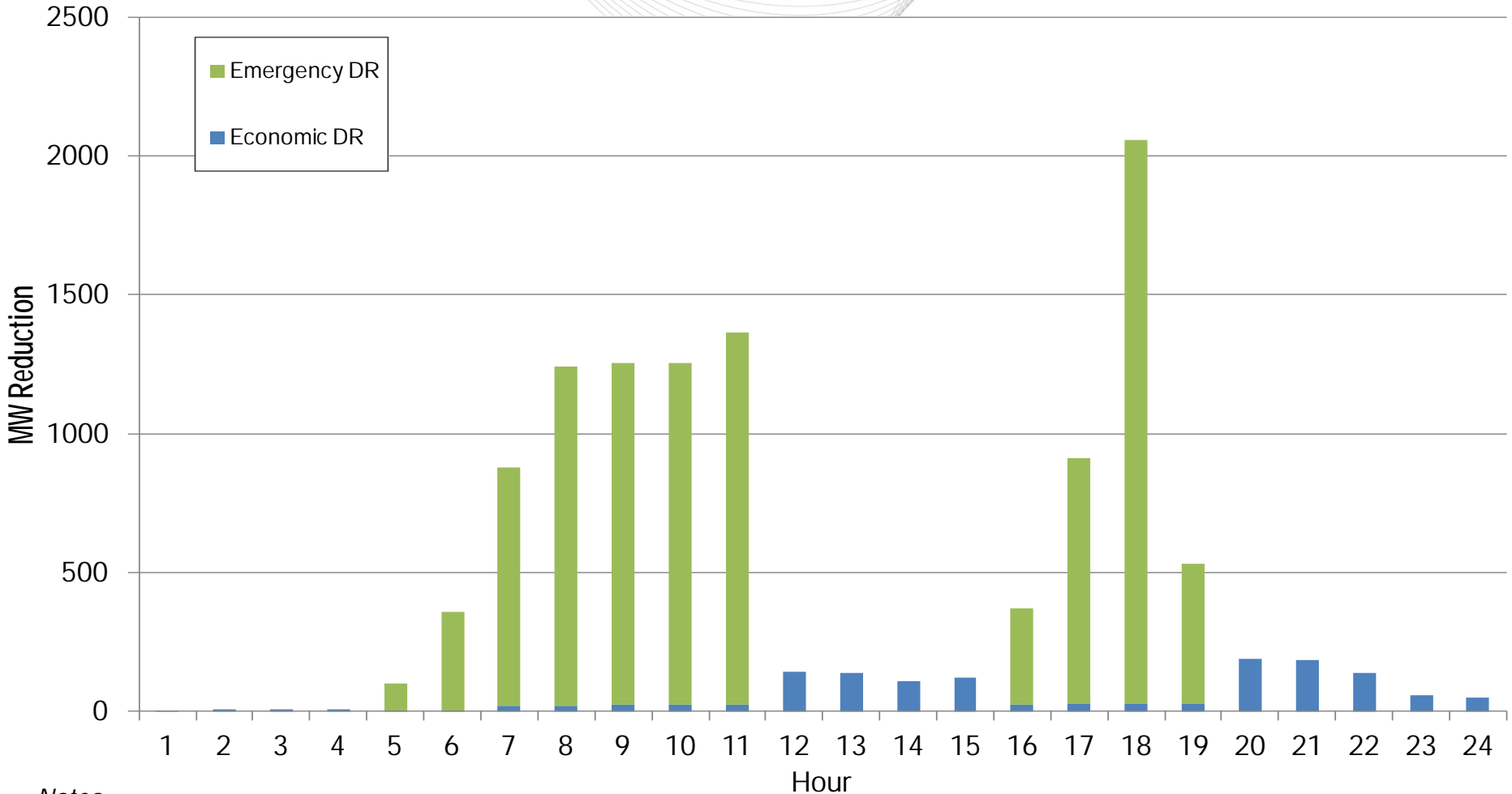
**Load Max
Emerg Gen
100% SR**







Estimated Demand Response in PJM: January 7, 2014



Notes:

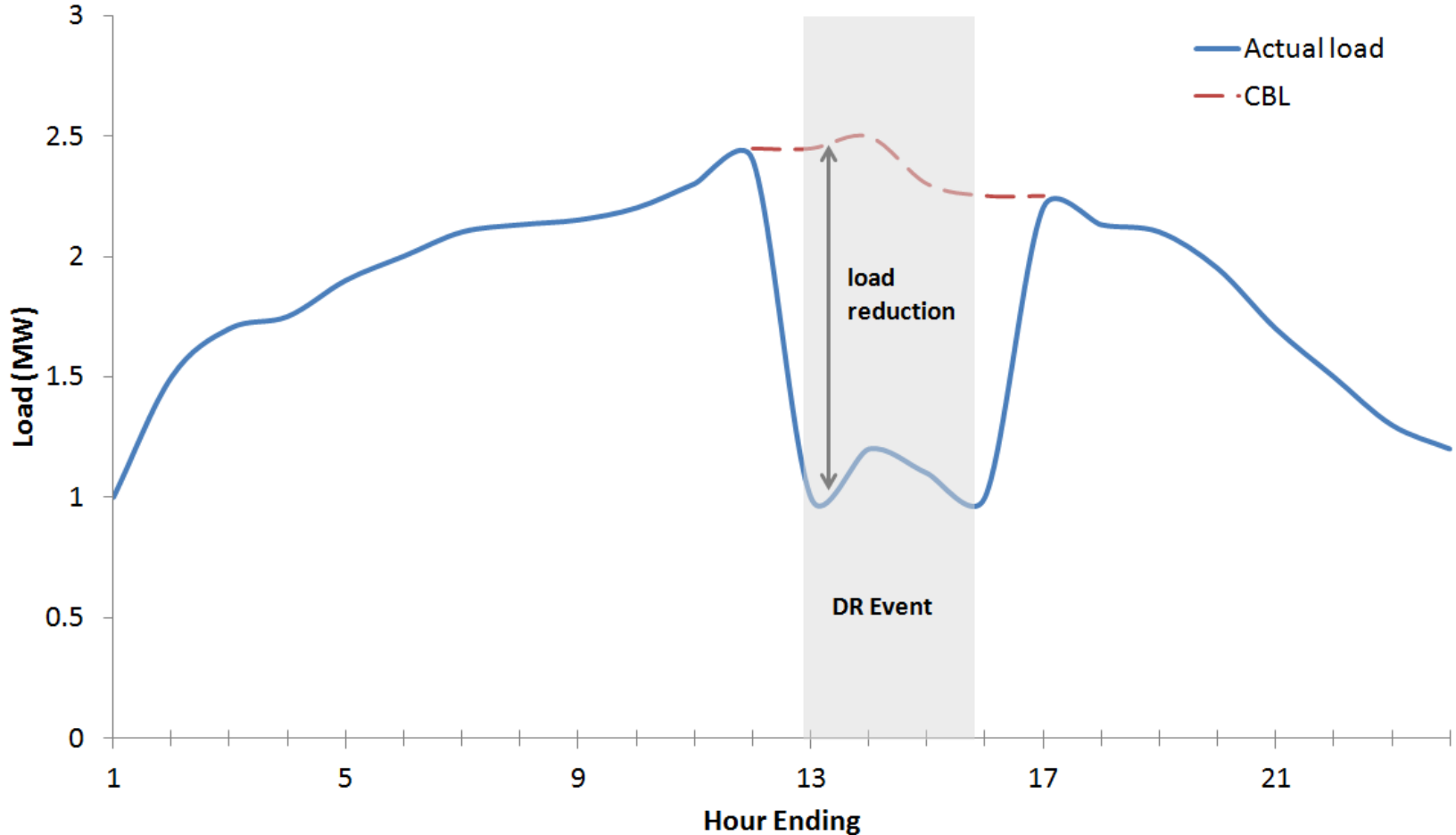
Emergency DR Amounts are CSP estimated Emergency Load Reductions adjusted down based on PJM observation (from morning event).

Actual load reductions are not finalized until up to 3 months after event.

- Cold!
 - High demand
 - Fuel issues
 - Forced outages
- Large units tripping
- Natural gas

- Demand Response Overview
- Emergency Operations
- **Measurement & Verification**
- Policy Issues

CBL (customer baseline) – forecast what resource would have used had there been no DR (demand response).



- **CBL/load forecast**
 - Must be reasonably accurate for participation
 - Accurate forecast → load reductions can be quantified
- **RRMSE (relative root mean square error) test**
 - Objective way to determine accuracy of CBL to forecast load
 - $RRMSE < 20\%$ → accurate CBL
 - $RRMSE > 20\%$ → Variable customers
- **Alternative CBLs**
 - May be developed to forecast variable load more accurately

CBL breakdown for all Economic DR registrations

CBL	MW	MW (%)	Registration (Count)	Registration (%)
3 Day Types with SAA (high 4 of 5)	1,122	47%	748	71%
Non-hourly metered sites DLC	768	32%	79	8%
MBL(Max Base Load)	270	11%	170	16%
Manual	140	6%	28	3%
3 Day Types (high 4 of 5)	107	4%	23	2%
7 Day Types with SAA (3 day average)	4	0%	3	0%
7 Day Types (3 day average)	0.1	0%	1	0%
3 Day Types with WSA (high 4 of 5)	-	0%	0	0%
Metered Generation	-	0%	0	0%
	2,411	100%	1,052	100%

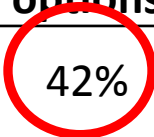
“Manual” CBL represents Same Day 3+2 method used last summer which was calculated and upload by CSP

- Variable resources – $RRMSE > 20\%$
 1. Develop CBL that reduces RRMSE with PJM approval **OR**
 2. MBL (Max Base Load) as CBL
 - Average of minimum load during prior days
 - Developed to ensure load reductions are not attributed to normal load fluctuations **OR**
 3. Cannot participate in Economic DR
- **Goal:** to develop new CBLs
 - More accurately forecast certain resources (Reduce RRMSE below 20%)
 - More resources can participate in economic DR

- Focused on all current registrations (115) that just missed accuracy threshold
 - RRMSE 20-40% using existing CBL methods
- Over 20 new CBLs tested
 - Including: moving average, median, ARIMA (autoregressive integrated moving average), 5 day type, etc., 3+2, match 3 day average
- Review of alternate CBLs from summer 2012
 - MBL (max base load)
 - 3+2

- 20 CBLs
 - Standard CBL: High 4/5 – 2/3 like days
 - 3 day type: Mean, Mean + SAA (Standard CBL)
 - 25% usage threshold
 - Past 5/5 – 3/3 like days
 - 3 day type: Mean, Median, Mean + SAA, Median + SAA
 - 5 day type: Mean, Median, Mean + SAA, Median + SAA
 - 7 day type: Mean, Median, Mean + SAA, Median + SAA
 - All hours mixed – Mean, Median
 - 3+2
 - ARIMA
 - MBL: Mean, Median
- 115 Registrations
 - RRMSE 20-40% using existing methods

	RRMSE range	Min. across existing CBL			Min. across variable options
		Match 3	Match 3 + 2	Match 3 + 2	
Percent of Registrations	<20%	0%	35%	13%	42%
	20%-30%	63%	39%	22%	39%
	>30%	37%	25%	64%	18%
Percent of MW	<20%	0%	8%	32%	37%
	20%-30%	26%	39%	12%	19%
	>30%	74%	53%	56%	44%

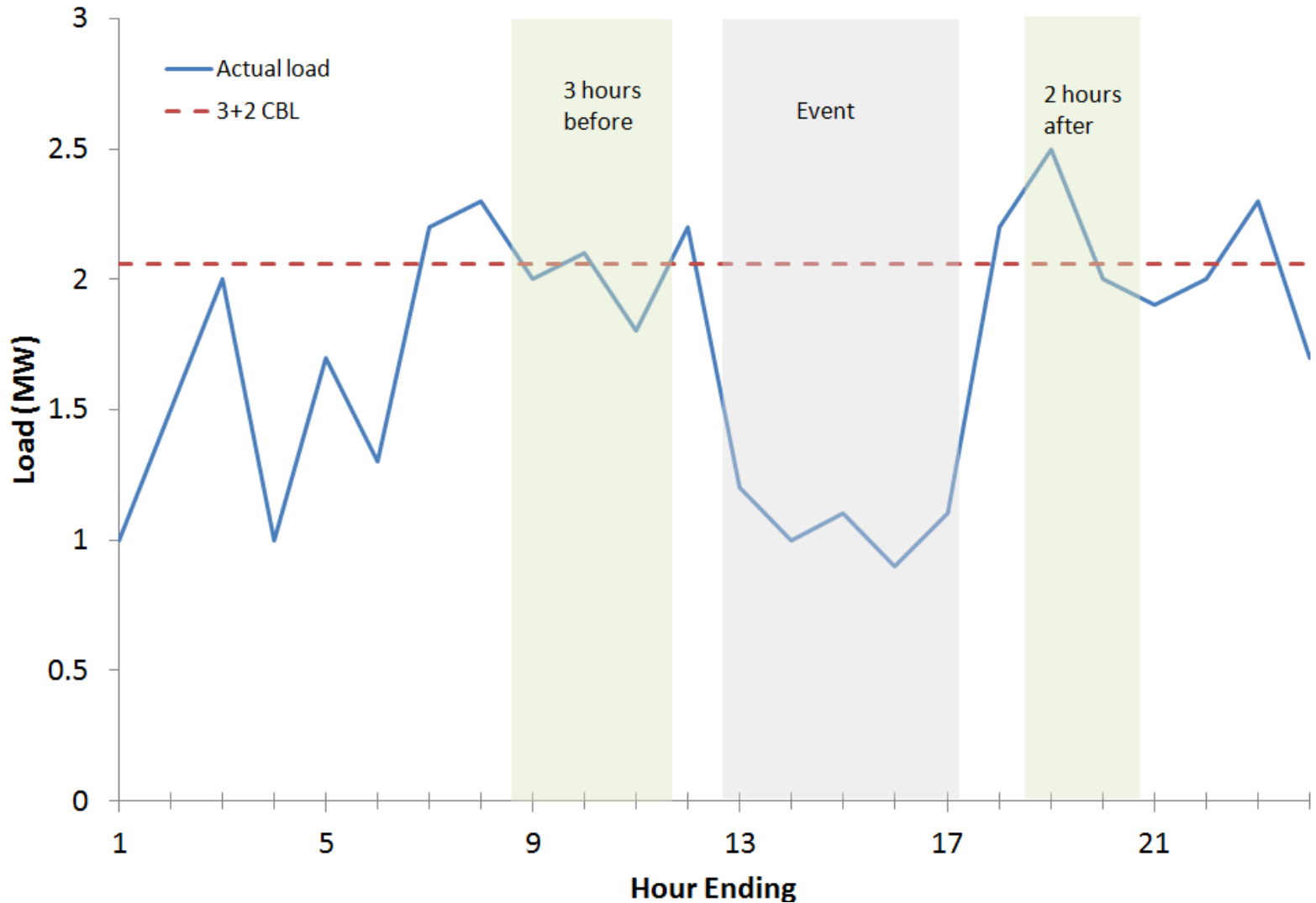


Expect to move 42% (48) of registrations with RRMSE score >20% and <40% (115) to new alternative CBL with RRMSE <20%

CBL 1 = Same Day (3 + 2)

- Average of 3 hours before event (after skipping one hour) and 2 hours after event (after skipping one hour)
- CSP may use only if no significant pre or post change in operations that will impact CBL calculation
 - Thermal load (pre-cooling or snapback)
 - Change in typical operations (including on-site generation schedule)
- No events during HE1, 2, 3, 23, 24 (to ensure hours are available to calculate CBL)

Designed for customer with daily usage that is fairly consistent (intra-day hourly volatility)

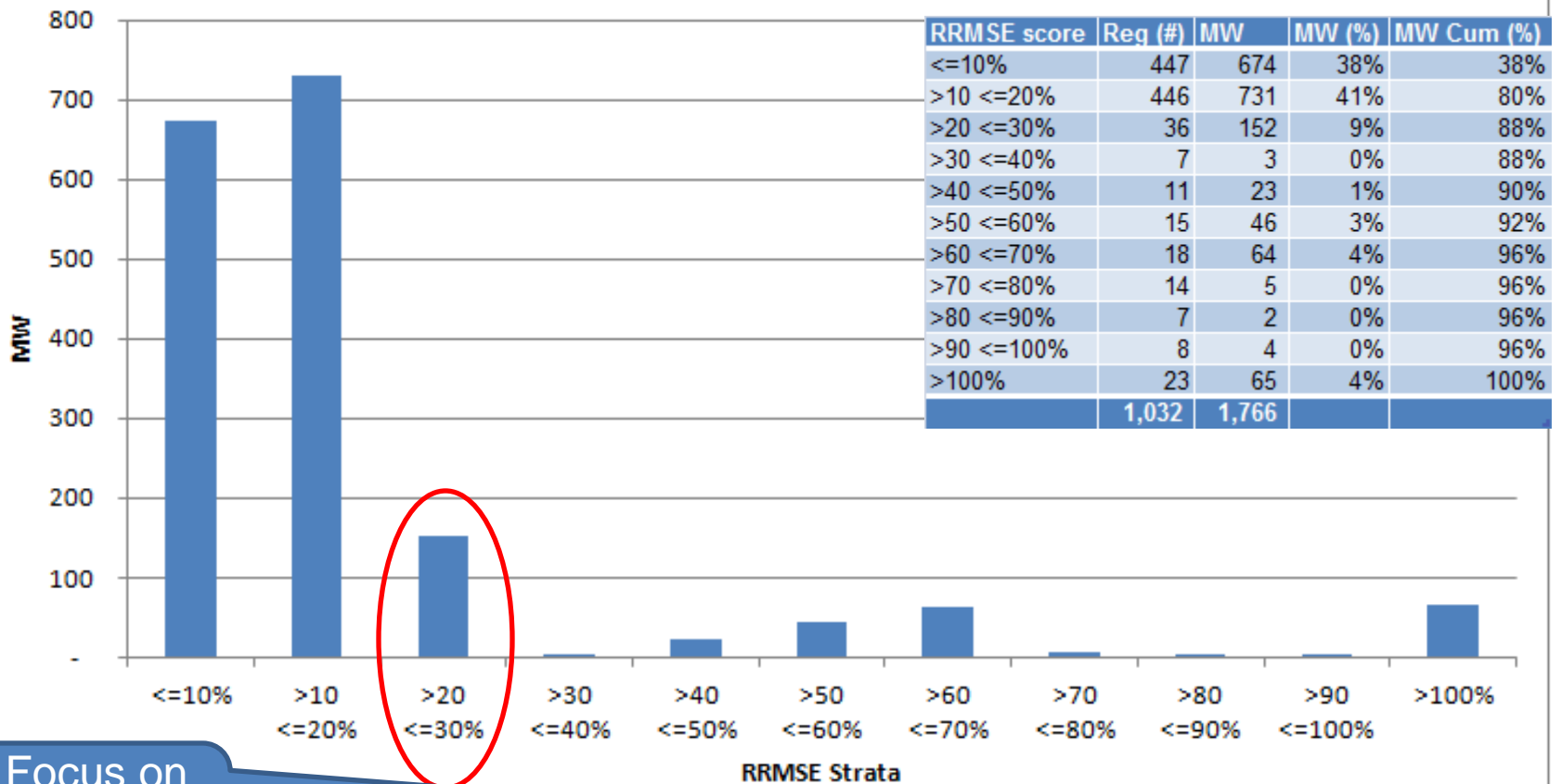


CBL 2 = Match Day (3 day average)

- Take average of 3 non-event days that have the most similar usage to non-event hours (exclude hour before and hour after event from non-event hours) on event day.
- Select 3 days to average. For each day in CBL basis day limit:
 - Take the difference between each comparison hour (non-event hours, excluding hour before and hour after event) from the event day and the same hour on look back day to determine the hourly difference for each comparison hour for each day.
 - Square all the hourly differences for each day and then sum the squared differences to determine the daily differences.
- Select the 3 days from the CBL Basis Day Limit with the smallest daily differences to determine the CBL Days.
- Average each of the event hours across the three CBL Days to determine the CBL for each event hour.
- First event hour to last event hour in operating day will comprise no more than 10 elapsed hours. This will ensure there are at least 12 non-event hours in the operating day to determine the selection of CBL days

Designed for customer daily usage pattern that vary and are not based on type of day (based more on production cycle for day)

MW registered by RRMSE score strata



Focus on these customers

- Demand Response Overview
- Emergency Operations
- Measurement & Verification
- **Policy Issues**

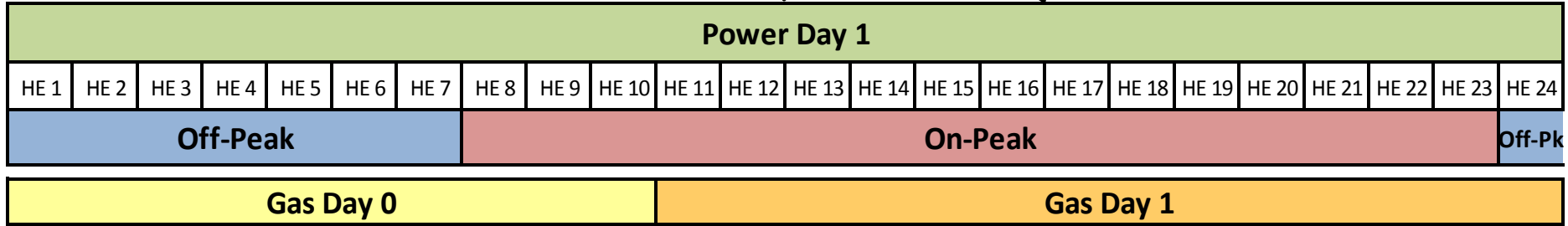
- Operational DR
- Capacity arbitrage
- Limiting DR in RPM auction
- Must offer
- M&V
- Sampling for residential customers in ancillary services
- Normal operations
- Gas/electric coordination

- Higher penetration NG
 - Higher price volatility
 - Lower reliability

Day Ahead Set Up

Power Day 2 Offers due

Power Day 2 Awards announced



Day Ahead Gas Trading

Intra-day Gas Trading

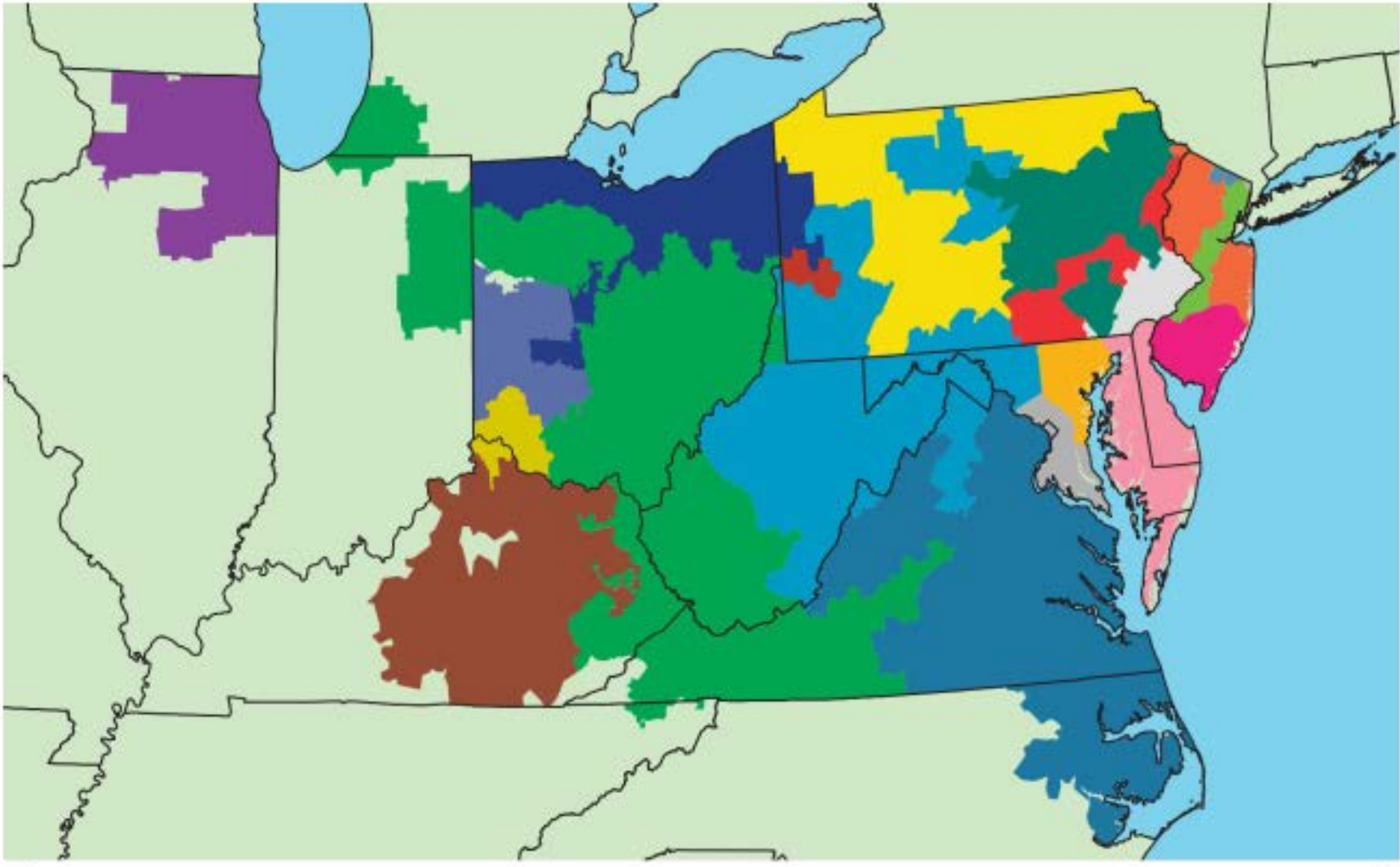
Gas Day 2 Timely nominations due

Gas Day 2 Evening nominations due

Current Eastern Time Schedule

- Value of fuel diversity
- Load forecasting
- Forecasting DR resource
- Measurement & verification for DR
- Electric/gas coordination
- Outage timing
- Incentives/market structure to reduce forced outages
- Interchange forecasting, market structure

Questions?



Category	2012	2013	Percent	2012	2013
	\$/MWh	\$/MWh	Change Totals	Percent of Total	Percent of Total
Load Weighted Energy	\$35.23	\$38.66	9.7%	71.8%	71.7%
Capacity	\$6.05	\$7.13	17.8%	12.3%	13.2%
Transmission Service Charges	\$4.78	\$5.20	8.7%	9.7%	9.6%
Reactive	\$0.43	\$0.80	87.6%	0.9%	1.5%
Energy Uplift (Operating Reserves)	\$0.79	\$0.59	(25.5%)	1.6%	1.1%
PJM Administrative Fees	\$0.42	\$0.42	(2.1%)	0.9%	0.8%
Transmission Enhancement Cost Recovery	\$0.34	\$0.39	15.5%	0.7%	0.7%
Regulation	\$0.26	\$0.24	(5.3%)	0.5%	0.5%
Black Start	\$0.03	\$0.14	437.7%	0.1%	0.3%
Capacity (FRR)	\$0.52	\$0.11	(79.4%)	1.1%	0.2%
Transmission Owner (Schedule 1A)	\$0.08	\$0.08	(0.3%)	0.2%	0.2%
Day Ahead Scheduling Reserve (DASR)	\$0.05	\$0.06	21.9%	0.1%	0.1%
Synchronized Reserves	\$0.04	\$0.04	3.1%	0.1%	0.1%
NERC/RFC	\$0.02	\$0.02	(1.2%)	0.0%	0.0%
RTO Startup and Expansion	\$0.01	\$0.01	(1.4%)	0.0%	0.0%
Load Response	\$0.01	\$0.01	41.6%	0.0%	0.0%
Non-Synchronized Reserves	\$0.00	\$0.00	127.3%	0.0%	0.0%
Transmission Facility Charges	\$0.00	\$0.00	17.2%	0.0%	0.0%
Total	\$49.07	\$53.92	9.9%	100.0%	100.0%

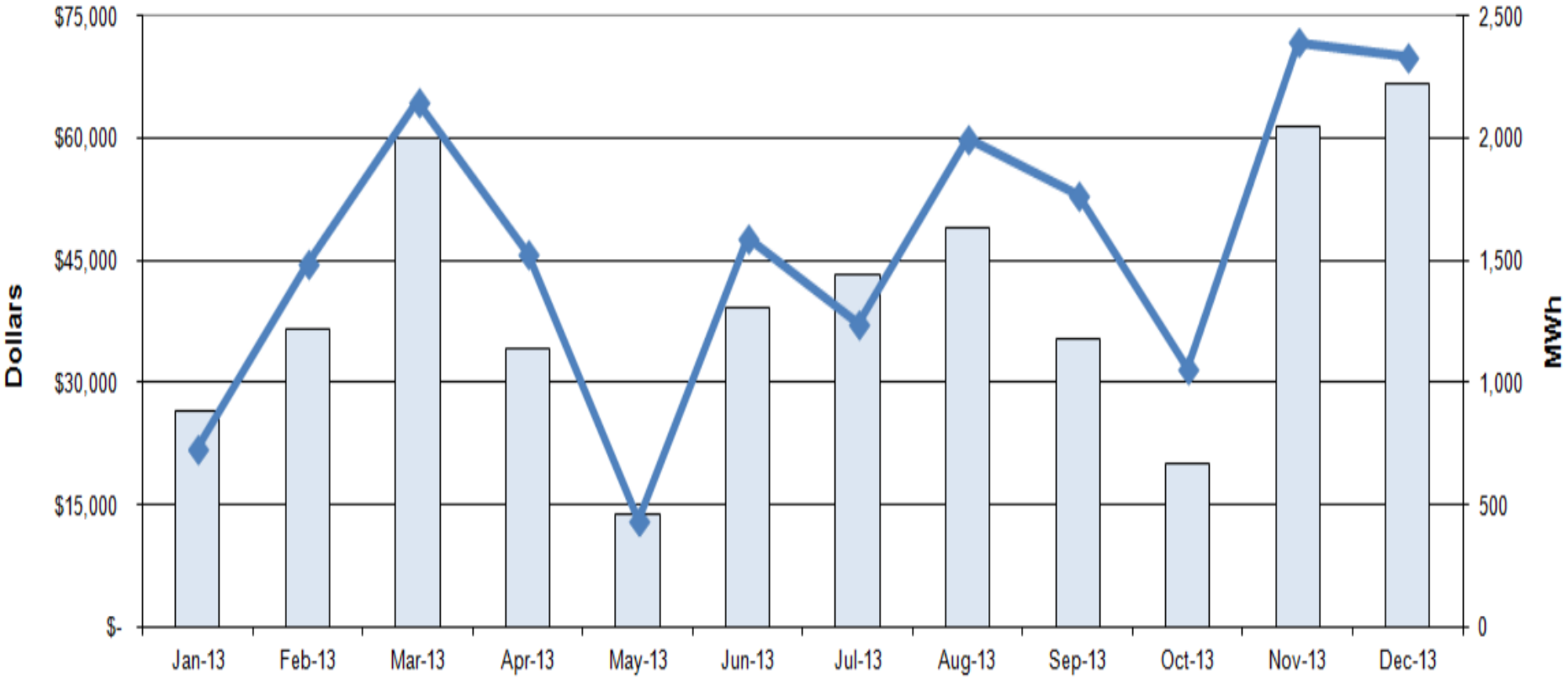
	2012	2013
Load	775,184 GWh	784,515 GWh
Generation	790,090 GWh	797,100 GWh
Imports (+) / Exports (-)	672 GWh	3,104 GWh
Losses	16,970 GWh	17,389 GWh
Regulation Requirement*	943 MW	784 MW
RTO Primary Reserve Requirement **	NA	2,085 MW
Total Billing	\$29.18 Billion	\$33.86 Billion
Peak	Jul 17, 2012 17:00	Jul 18, 2013 17:00
Peak Load	154,344 MW	157,508 MW
Load Factor	0.76	0.76
Installed Capacity	As of 12/31/2012	As of 12/31/2013
Installed Capacity	181,990 MW	183,095 MW

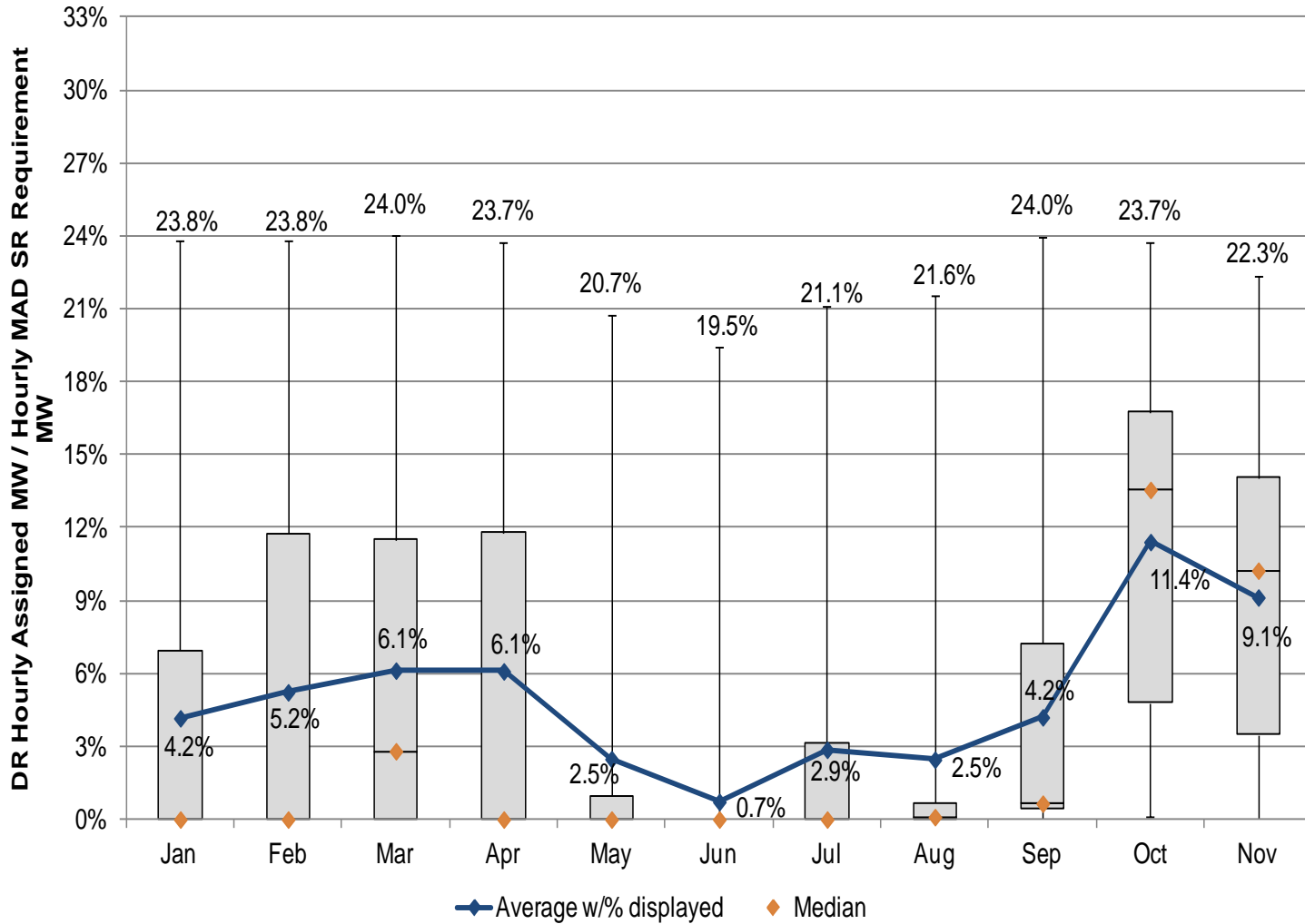
* Daily average

** Regulatory requirement remained 2,063MW throughout the year. Amount show is daily average

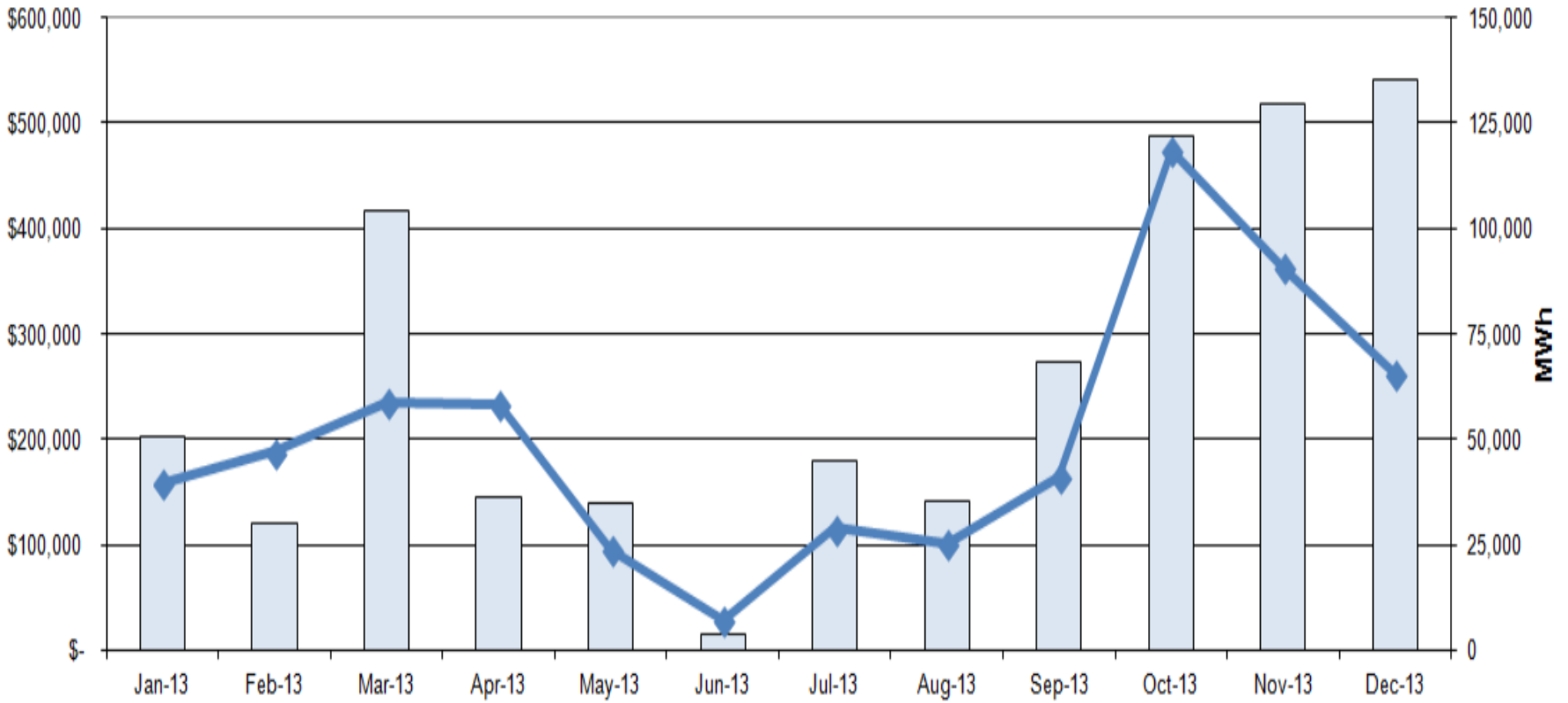
Year	Total MWh	Total Credits	\$/MWh
2003	19,518	\$833,530	\$42.71
2004	58,352	\$1,917,202	\$32.86
2005	157,421	\$13,036,482	\$82.81
2006	258,468	\$10,213,828	\$39.52
2007	714,148	\$31,600,046	\$44.25
2008	452,222	\$27,087,495	\$59.90
2009	57,157	\$1,389,136	\$24.30
2010	74,070	\$3,088,049	\$41.69
2011	17,398	\$2,052,996	\$118.00
2012	145,019	\$9,284,118	\$64.02
2013	133,071	\$8,035,761	\$60.39

Total Payments
 Total MWh





Total Payments
 Total MWh



Requirement	Limited DR	Extended Summer DR	Annual DR
Availability	Any weekday, other than NERC holidays, during June – Sept. period of DY	Any day during June-October period and following May of DY	Any day during DY (unless on an approved maintenance outage during Oct. - April)
Maximum Number of Interruptions	10 interruptions	Unlimited	Unlimited
Hours of Day Required to Respond <i>(Hours in EPT)</i>	12:00 PM – 8:00 PM	10:00 AM – 10:00 PM	Jun – Oct. and following May: 10 AM – 10 PM Nov. – April: 6 AM- 9 PM
Maximum Duration of Interruption	6 Hours	10 Hours	10 Hours
Notification	Must be able to reduce load within 2 hours of notification		
Event Compliance	Data due 45 day after end of event month		
Test Compliance	Mandatory test required if no emergency event called		

- Revenue
 - RPM clearing price * Capacity volume
 - \$6,000 - \$80,000 per year for 1 MW (based on prior auctions)
 - Energy paid at higher of LMP or offer price
- Penalties
 - Resource Capability Deficiency
 - Annual Revenue + Higher of (20% * Revenue OR \$20/MW-day)
 - Event Compliance
 - On Peak: Lesser of (1/number of events or 50%) * Annual Revenue
 - Off Peak: 1/52 * Annual Revenue

- Focused on all current registrations (115) that just missed accuracy threshold
 - RRMSE 20-40% using existing CBL methods
- Over 20 new CBLs tested
 - Including: moving average, median, ARIMA (autoregressive integrated moving average), 5 day type, etc., 3+2, match 3 day average
- Review of alternate CBLs from summer 2012
 - MBL (max base load)
 - 3+2