Technical Bulletin

2009-06-04

Explanation of Conditions Contributing to Real-Time Price Volatility For May 19, 2009

June 15, 2009

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1. Introduction

May 19, 2009, Real-Time Market encountered more sustained LAP prices above $500 in Southern California than other days. As a result, there is interest in more detailed analysis and explanation of the conditions and solutions that resulting the Real-Time Market outcomes. The following provides detailed review of Real-Time Market results for May 19, 2009.

2. Detailed discussion:

Analysis of May 19, 2009 Real-Time Market can be divided up into 2 time periods:

Period 1: 10:30-12:00
Period 2: 15:00-16:45

Prior to the detailed analysis of specific periods and the events, it should be noted the conditions leading up to May 19th reflect a period of significant amount of Maintenance work that had been constraining the system for several weeks. Some of the more significant maintenance work underway on May 19 included clearance on a Midway-Vincent line (Path – 26) and Vincent bus work limiting Path 26 from 4000MW to 1700 MW, and Imperial Valley 500/230 kV Bank-81 clearance, limiting Imperial Valley generation & imports from CFE to SDGE.

The actual load forecast for the CAISO on May 19th was approximately 34,600MW with high than normal temperatures in Southern California. The previous day, May 18th, higher loads across the system were experienced but higher proportion of load in Northern California due to higher than normal temperatures across the system. As a result of the significant shift of load pattern, the use of Load Distribution Factors that were determined from previous days did not provide an accurate distribution of load for May 19th. This change in weather pattern leading to change in load pattern contributed to actual and market flow differences on Path 26 for May 19th Day-Ahead and Real-Time Markets. Refer to Table 1 for comparison of HE16 actual from May 18th and May 19th.

The loading on Path 26 in the DAM (IFM and RUC) did not indicate loading approaching the 1700 MW derated, even though DAM used biasing to enforce the Path 26 limit at 85% of the 1700 MW limit. Several factors may have contributed to the DAM difference in flow: 1) resource deviations or resources not scheduling in DAM, 2) the higher than forecasted temperatures in Southern California on May 19 meant that neither the bid-in demand schedules in IFM, nor the demand forecast and load distribution factors used in RUC, could anticipate the actual demand south of Path 26, 3) specific RT events including the curtailment of the Pacific DC Intertie, and specifics of mitigation of the Victorville branch group and Imperial Valley 500/230 kV Bank 81, could not be anticipated in the DA timeframe, and 4) both IFM and RUC consider hourly scheduling intervals, which do not account for variations in RT conditions within the hourly intervals, and therefore do not consider one- to ten-minute peaks in flows that exceed the hourly averages.

Real Time Path 26 flows exceeded the 1700 MW limit atleast three times on 5/19, at 11:19 and 11:23 (flow approx 1725 MW), 12:16 (flow 1852 MW). However, no violation occurred. Refer to Figure 2 providing Real-Time flow exceeding limit.

Figure 1: Path 26 Hourly Flows

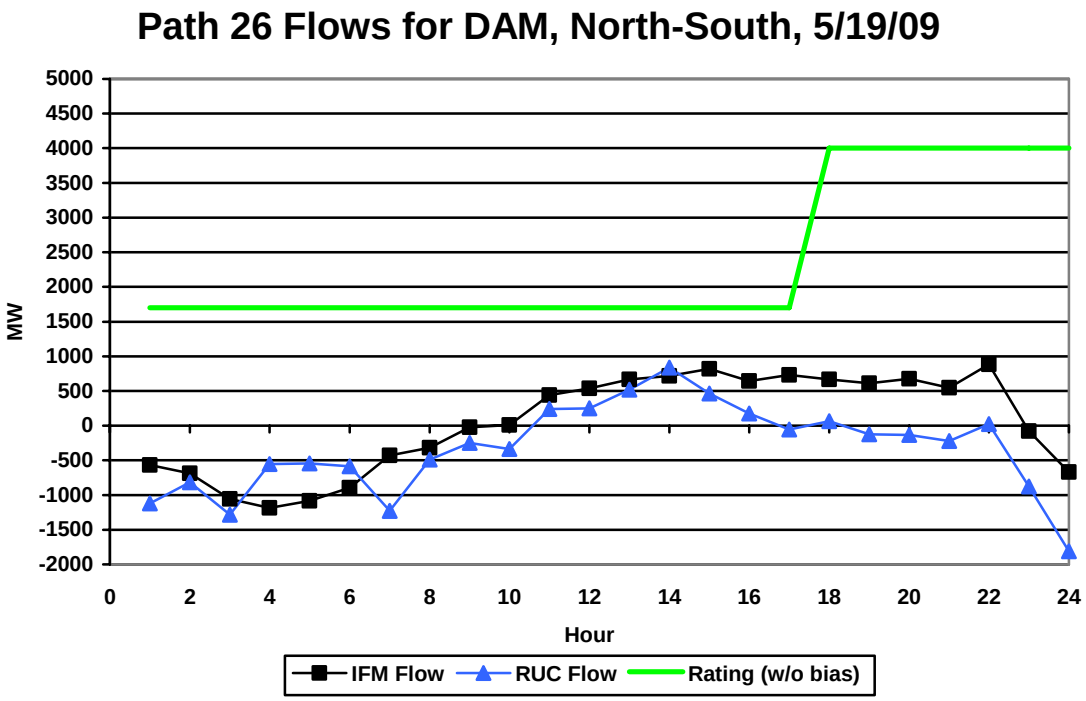


Figure 2: Real-Time Path 26 Flows

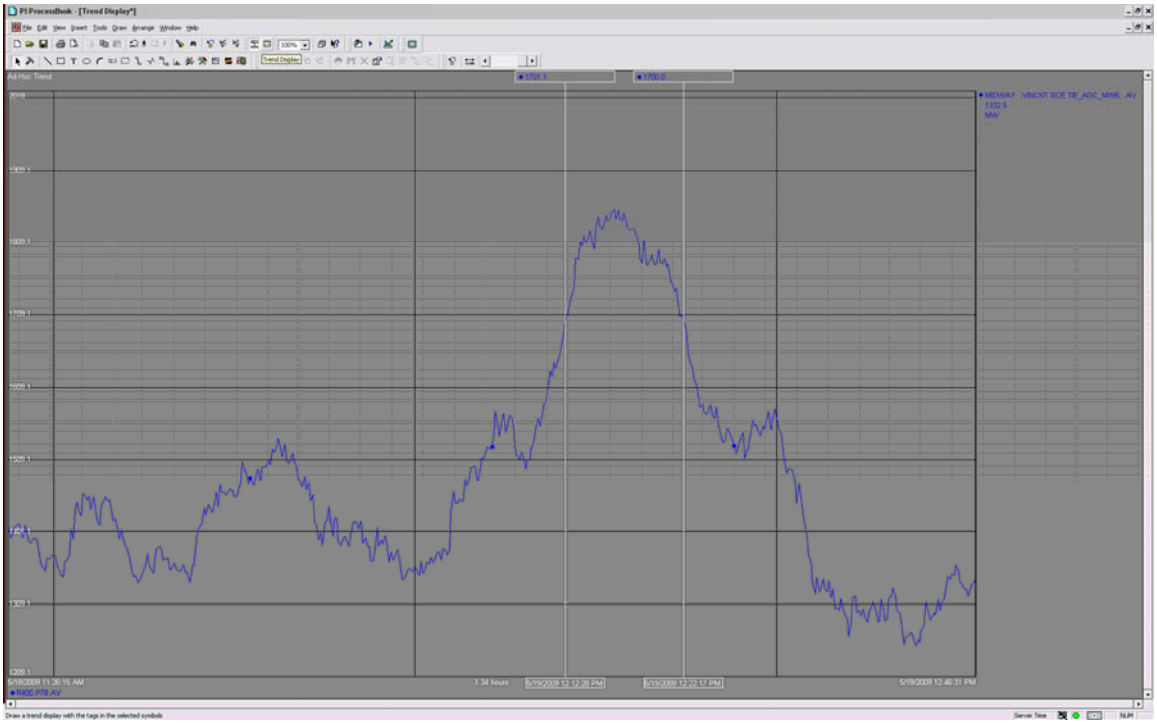


Table 1: Comparison of HE16 Actual Load

	18-May		19-May		Difference (May 19th-May 18th)		
	Load	%	Load	%	Load	%	Shift (%Diff x May 19th Load)
PGE-TAC	16363	45%	14961	43%	1402	2%	605.061
SCE-TAC	16931	47%	16530	48%	401	-1%	-423.603
SDGE-TAC	2925	8%	2964	9%	-39	-1%	-181.458
Total	36219		34455				

Table 2: Wind Generation

Hour	Day-Ahead Wind Gen	Real-Time Wind Gen
1	353.62	947.449
2	353.62	939.9125
3	353.62	931.35
4	353.62	927.74
5	353.62	880.83
6	353.62	881.97
7	353.62	873.9505
8	353.62	868.75
9	353.62	873.8
10	353.62	863.31
11	353.62	866.72
12	353.62	852.01

Figure 3: SCE+SDGE Load

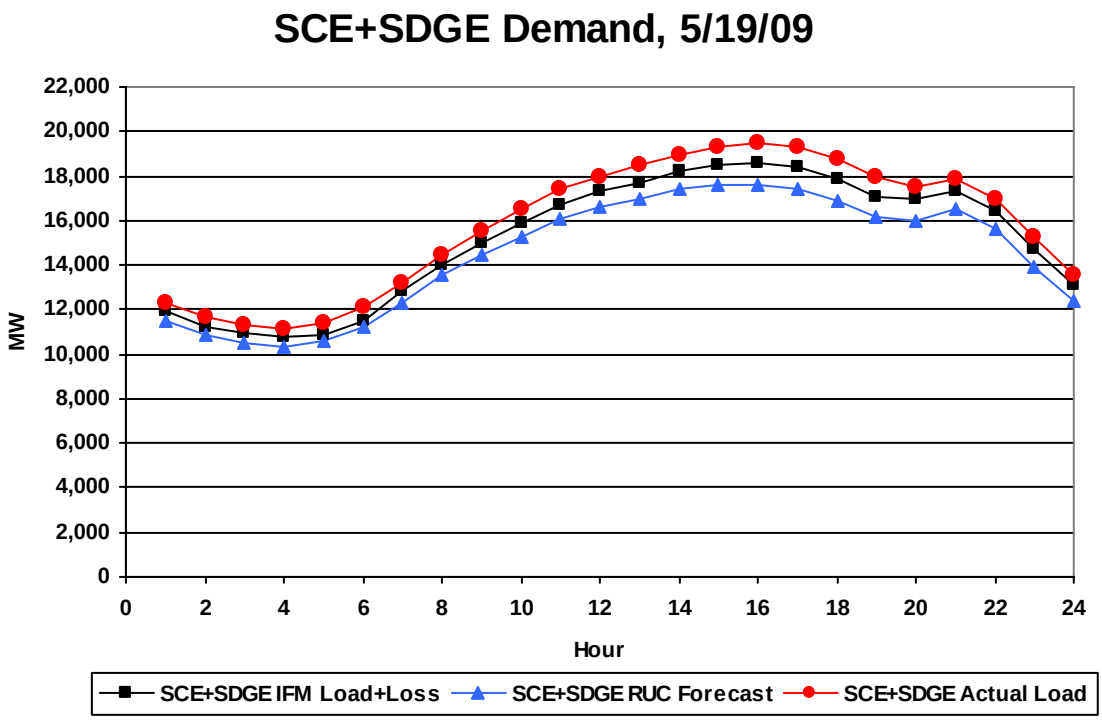


Figure 4: PG&E Load

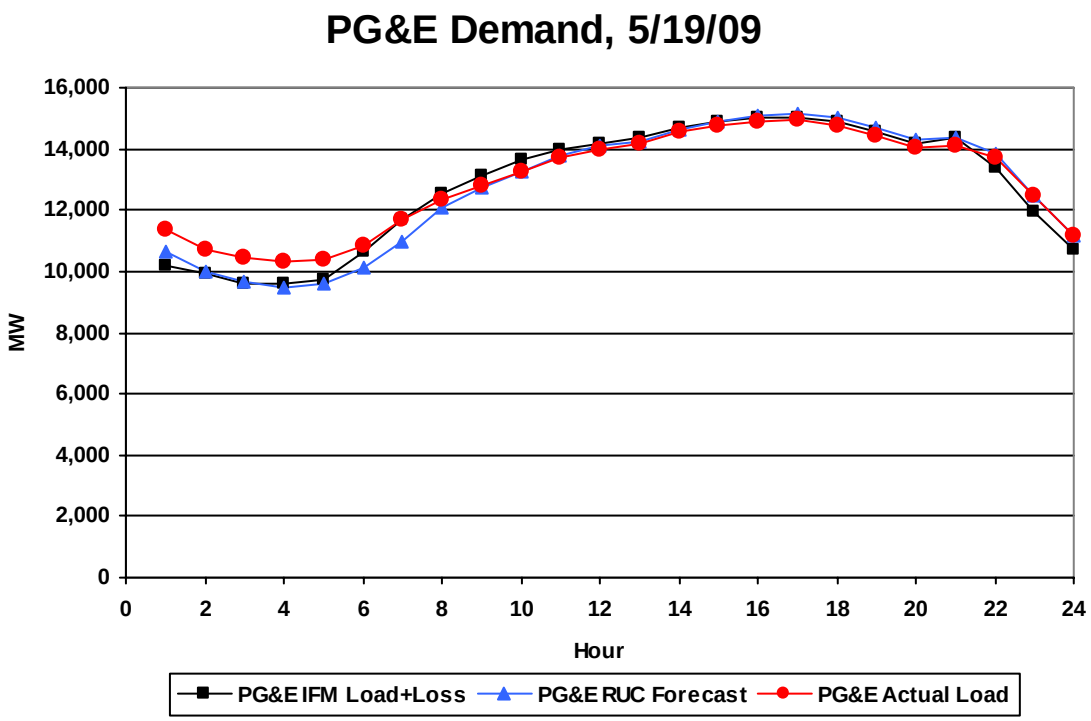
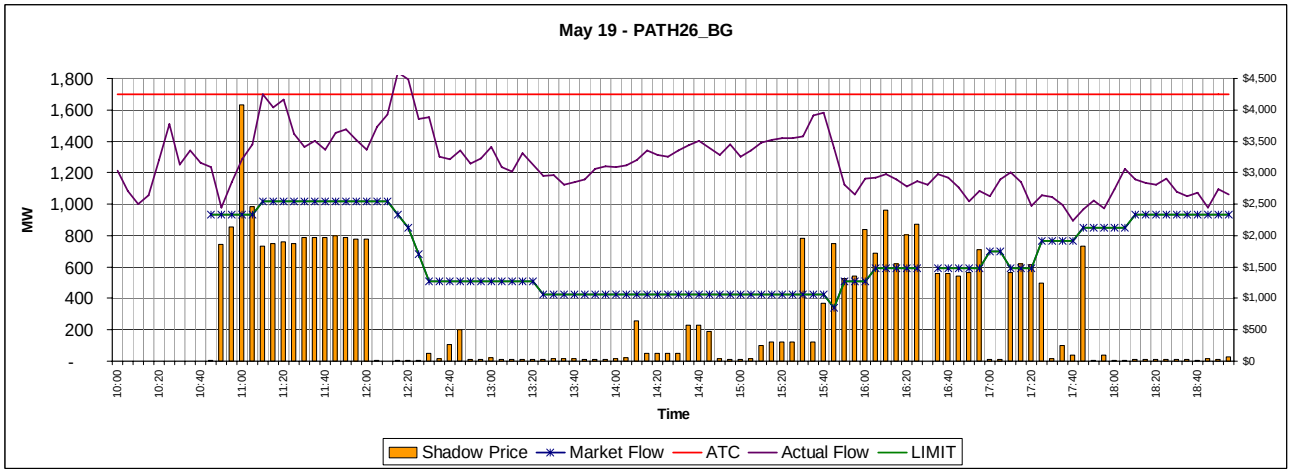


Figure 5: Comparison of Path26 Flows, Real-Time Dispatch Shadow Price



Period 1: 10:30-12:00

Prior to 10:50, CAISO was informed that schedules on the Pacific DC Intertie (PDCI) were being curtailed due to a mylar balloon in the line. As a result of expectation of increased flow on the Path 26 and as a precautionary measure in the event of a PDCI block, Path26 market limit was biased down to 935MW (55% of the 1700 MW) to ensure flows are controlled below the limit. PDCI schedules were cut to 0 MW for HE12 and HE13 Even with this limit binding, the actual flows continued to increase to the limit of 1700MW at 1110. At 1102 the CAISO was informed the balloon in PDCI was dislodged and the PDCI would remain in service at low power order. Scheduling was available for HE 13 but HASP had already run with a 0 availability for HE 13. Since the PDCI was available again, circulation was established to help relieve Path26 flows. In addition to the Path26 constraint, VICTVL_BG (flowgate) and IV-BNK_OUT_NG (nomogram) are also at or near their binding limit.

Simultaneous constraints on Path26, VICTVL_BG (due to Victorville-Lugo loading) and IV-BNK_OUT_NG, in addition to PDCI curtailments create complicated flow interplay. PDCI (North to South) ramping down lowers VIC-Lugo Flows but increases Path26 (North to South) flows. High PDCI (North to South) flows lower Path26 (North to South) flows, increase flow pressure on the VIC-Lugo. Also, some generation in Southern California which is typically effective in lowering both Path 26 & VIC-Lugo North to South flows, was constrained not be redispatched due to the IV-BNK_OUT_NG being constrained.

At times there was insufficient capacity unencumbered by awarded regulation or operating reserve SP26 to relieve the constraint within one 5 minute interval dispatch as the load continued to increase and actual flows increased. As a result Path26 became binding in the market and at times in the Scheduling Run relaxed at price of $2000 constraint relaxation, consistent with our constraint parameters. When solving the Pricing Run based on constraint relaxed in the Scheduling Run, the optimization found there were re-dispatch solutions in between the $500 Pricing Run parameter and the $2000 price for reducing scheduled exports

Prior to the PDCI event the dispatch of non-spin reserves was being skipped to conserve reserves. During the period Path 26 had become constrained time period, RTUC did at times also observe and attempted to resolve the Path26 constraint. Due to the sustained constrained conditions, RTUC did commit short start resources as well. In addition after the PDCI event some additional short-start resources some of which were providing non-spin capacity were manually started by dispatcher.

Following is a more detailed exploration of the RTD 5 minute results as prices rise from $49 to $2000 in Southern California from Interval 10 in HE11 to Interval 12 in HE11.

Default LAP prices for the two 5-minute intervals are provided in Table 3:

Table 3: Trade-Date May 19, 2009, HE11

	PG&E	SCE	SDGE
Interval 10 of HE11	$40.88	$48.69	$44.73
Interval 12 of HE11	$80.46	$2086.78	$1890.72

Relevant transmission constraints are:

1. PATH26_BG (flowgate) – effective limit 935MW, which is 55% of the 1700MW unbiased limit
2. VICTVL_BG (flowgate) – effective limit 2208MW, which is 92% of the 2400MW unbiased limit
3. IV-BNK_OUT_NG (nomogram) – effective 800MW, which is 100% of the 800MW unbiased limit.

Consider the first case with binding interval 10. All 3 transmission constraints are binding without relaxation. Pricing run shadow prices of these constraints are listed below.

Table 4: Pricing Run Shadow Prices HE11, Interval 10

PATH26_BG	VICTVL_BG	IV-BNK_OUT_NG
$10.22	$42.31	-$1222.56

Although the nomogram IV-BNK_OUT_NG is heavily congested, congestions of the other two flowgates PATH26_BG and VICTVL_BG are quite mild, especially for PATH26_BG. As a result, LAP prices for SCE and SDGE default LAPs are relatively low. We find no uneconomically curtailment of export and import self-schedule. Though comparing with the Interval 12 case, we find that for Interval 10 generating resources south of PATH26 including resource specific system resources, we still have about 335MW of room to dispatch upward at this time. Therefore, in interval 10, conditions are such that economically bid in capacity has not been exhausted even though constraints are binding.

Marginal resources of pricing run, their scheduling run and pricing run MW values and their pricing run LMPs are listed in the Table 5 below:

Table 5: Marginal Resources, HE11, Interval 10

Pricing Run Marginal Resources	Pricing Run LMP
UNITA	$28.72
UNITB	$44.79
UNITC	$39.53

LMPs of the first 3 marginal resources are equal to their bid prices respectively.

In second case Interval 12 with binding interval 10 minutes later, system load has increased by about 270MW with 54.40% accounted for the area south of PATH26. All generating resources in Southern California including resource specific system resources are dispatched to their maximum levels. Import to the south excluding resource-specific system resource is reduced by 705MW comparing to the previous case and import at NOB_ITC tie-point accounts for 597MW reduction due to the PDCI event. In the meantime, export from the south also reduces by 447MW comparing to 10 minutes ago. PATH26_BG and IV-BNK_OUT_NG are binding and VICTVL_BG undergoes relaxation for 9.1MW into order to bring in extra energy through the ADELANTO-VICTORVILLE area. Flow direction for PATH26_BG is from north to south, for VICTVL_BG from VICTORVILLE to LUGO and for IV-BNK_OUT_NG into SDGE area. Pricing run shadow prices of the binding constraints are:

Table 6: Pricing Run Shadow Prices HE11, Interval 12

PATH26_BG	VICTVL_BG	IV-BNK_OUT_NG
$2133.90	$2632.33	-$1301.37

As generating resources located south of PATH26 are run out unloaded capacity to meet load, 339.5MW of self-schedule export at various tie-points in south California are internally uneconomically curtailed[1] at $2000 penalty price in scheduling run. Marginal resources of pricing run, their scheduling run and pricing run MW values and their pricing run LMPs are listed in the Table 7 below:

Table 7: Marginal Resources, HE11, Interval 12

Pricing Run Marginal Resources	Scheduling Run MW	Pricing Run MW	LMP in Pricing Run
UNIT D	479.056MW	475.910MW	$43.53
UNIT E	0MW	3.431MW	-$100.457
TIE A	50MW	49.86MW	$22.00
TIE B	21.908MW	21.908	$500

LMPs of UNIT D and TIE A are their respective bid prices. LMP of TIE B is the bid cap since this export is curtailed uneconomically in scheduling run. LMP of UNIT E is determined through the binding of the ramping constraint as this resource is under constrained ramping from the current interval to the next.

[1] No actual export schedules were cut. After HASP in order to avoid over-constraining the solution intertie are allowed to move within the solution at penalty of $2000.

Both UNIT D and UNIT E are located north of PATH26. From pricing run to scheduling run, the more expensive generator UNIT D is dispatched up while the less expensive generator UNIT E is dispatched down. This is symptom of the lossless shift factor effect that such adjustment could reduce the flow of PATH26 from north to south and results in high shadow price at $2133.90 in pricing run[2].

Table 8 provides for the transmission limit biasing that was occurring. Path26 biasing was necessary due to the fact that actual flows were greater than then the observed market flow while actual flows were approaching or at actual limit.

Table 8: Biasing

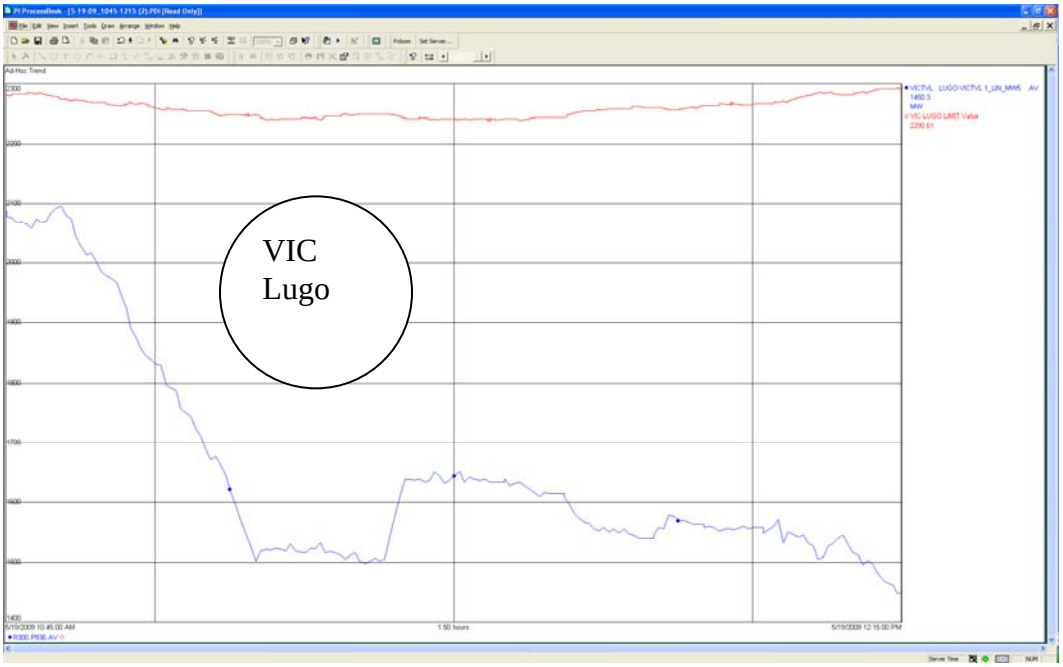
Path/Branch	Time	Bias	Notes
Path26	10:27	55%	RTD and RTUC: Reliability Margin and Measured Flow Diff.
Path26	11:02	60%	RTD Reliability Margin and Measured Flow Diff.
Path26	12:12	50 %	RTD and RTUC Reliability Margin and Measured Flow Diff.
Vic-Lugo	9:32	90%	Reliability Margin
Vic-Lugo	9:57	92%	Reliability Margin
Vic-Lugo	10:57	97%	Reliability Margin
Vic-Lugo	11:01	100%	Reliability Margin and Measured Flow Diff.
Vic-Lugo	11:04	105%	Reliability Margin and Measured Flow Diff.
IV-BNK_OUT_NG	11:15	110%	Actual flow high but below actual flow
IV-BNK_OUT_NG	11:52	105%	Actual flow high but below actual flow

Black Line- PDCI Flow
Blue Line – Path26 Actual Flow
Red Line – Unscheduled Flow (N-S on Path26)

[2] Refer to Technical Bulletin 2009-05-02 SDG&E Constrained 5-minute Default LAP Price on 4/19/09 http://www.caiso.com/23b4/23b4caaf479b0.pdf

Figure 6: PDCI/P-26 and Loop Flow multi Scale

Figure 7: Victorville-Lugo



Period 2: 15:00-16:45

As the afternoon Peak approach, the actual loading level on Path26 again approached the actual limit relatively quickly while at the same time PDCI was heavily scheduled. By this time Path26 was already biased significantly down accounting for large differences in actual flow and market flow. As the actual flows approach the actual limit, the dispatch results to keep the market flows below their biased limit became more constrained

At 1617 we got a bad reading on Path 15 that gave us the indication that we had exceeded the North to South limit. A contingency run was executed until it could be verified that the cause was bad telemetry.

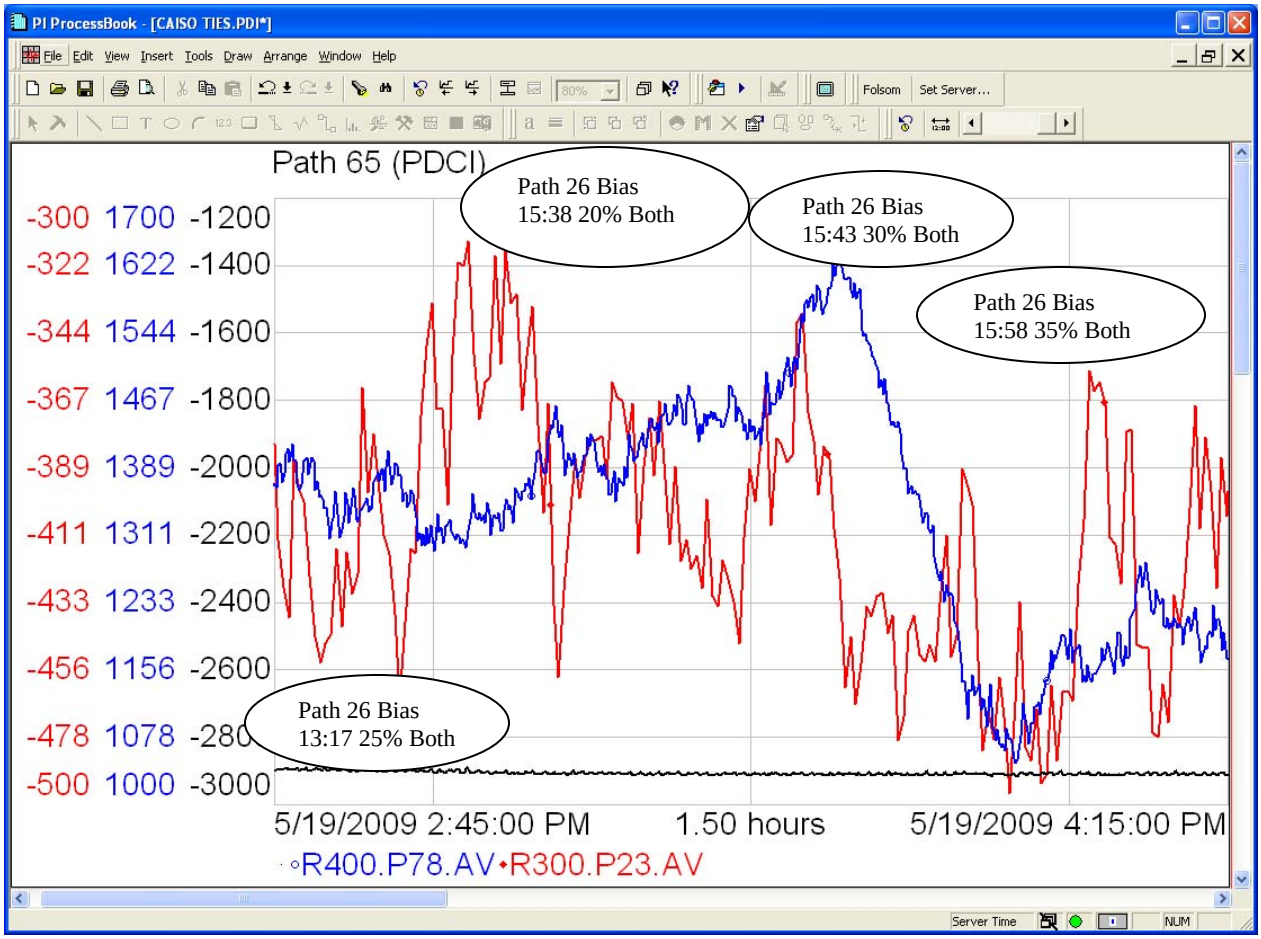
As a result of these events, the continuous interplay with flows on PDCI, Path26, VICTVL_BG, the dynamic nature of conditions going across the peak, the CAISO cautiously revised the bias conditions as conditions demonstrated improvement.

Once again during this period, the available 5 minute ramping capacity became constrained south of Path26. As a result of the ramp-constrained capacity, prices then resulted from re-dispatch of resources north of Path26. RTUC did also observe the constrained conditions and committed short-start resources. However, short-start resources that were providing non-spin capacity were not started to protect operating reserves.

Table 9: Biasing

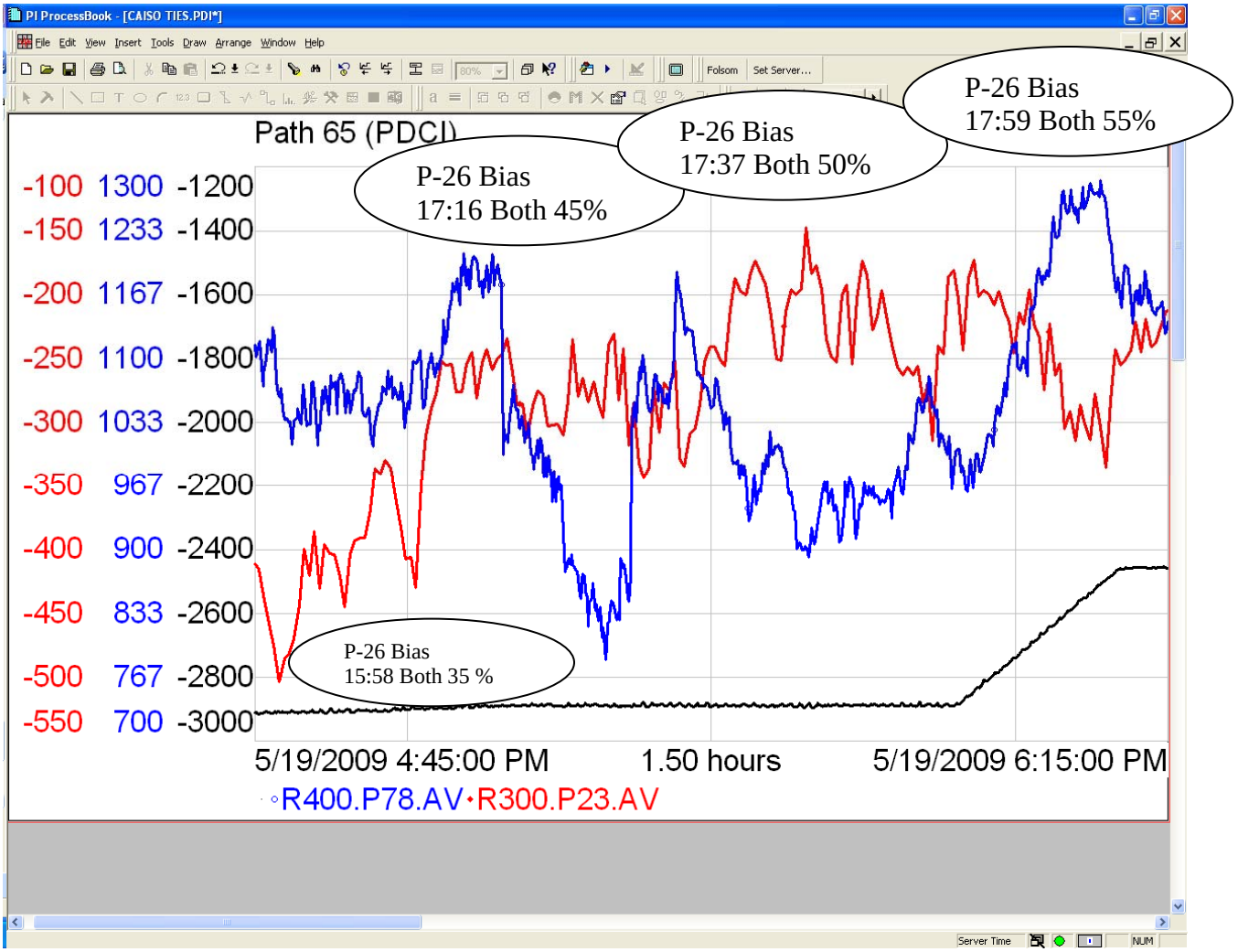
Path/Branch	Time	Bias	Notes
Path26	13:17	25%	RTD and RTUC: Reliability Margin and Measured Flow Diff.
Path26	13:38	20%	RTD Reliability Margin and Measured Flow Diff.
Path26	15:43	30 %	RTD and RTUC Reliability Margin and Measured Flow Diff.
Path26	15:58	35 %	RTD and RTUC Reliability Margin Increase as Measured Flow Diff improves
Path26	17:16	45%	RTD and RTUC Reliability Margin Increase as Measured Flow Diff improves
Path26	17:37	50%	RTD and RTUC Reliability Margin Increase as Measured Flow Diff improves
Path26	17:59	55%	RTD and RTUC Reliability Margin Increase as Measured Flow Diff improves

Figure 8: Flow Conditions 1445-1645



Black Line- PDCI Flow
Blue Line – Path26 Actual Flow
Red Line – Loop Flow (N-S on Path26)

Figure 9: Flow Conditions 1645-1815



Black Line- PDCI Flow
Blue Line – Path26 Actual Flow
Red Line – Loop Flow (N-S on Path26)

Figure 9: Victorville-Lugo 1445-1615

Vic – Lugo

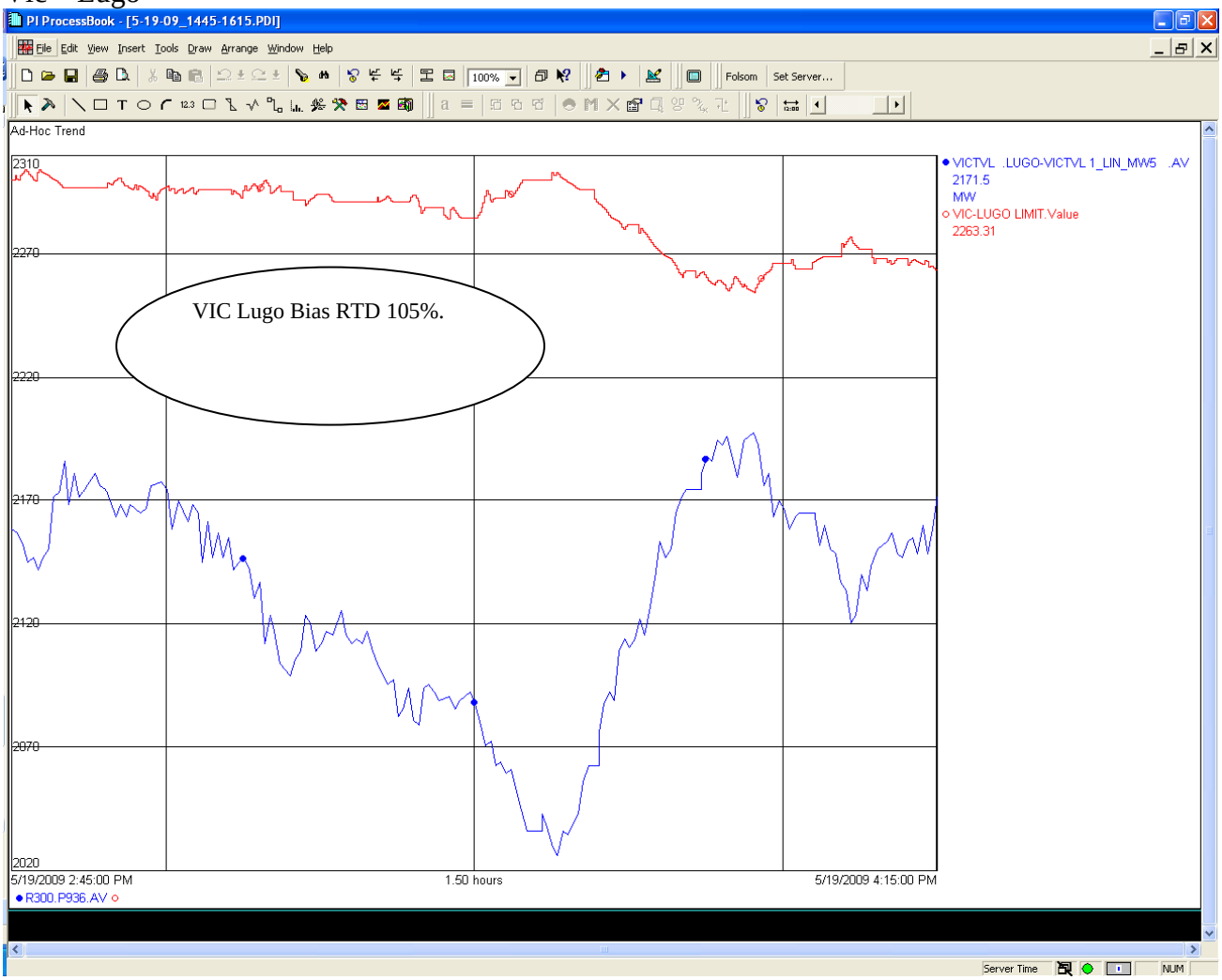
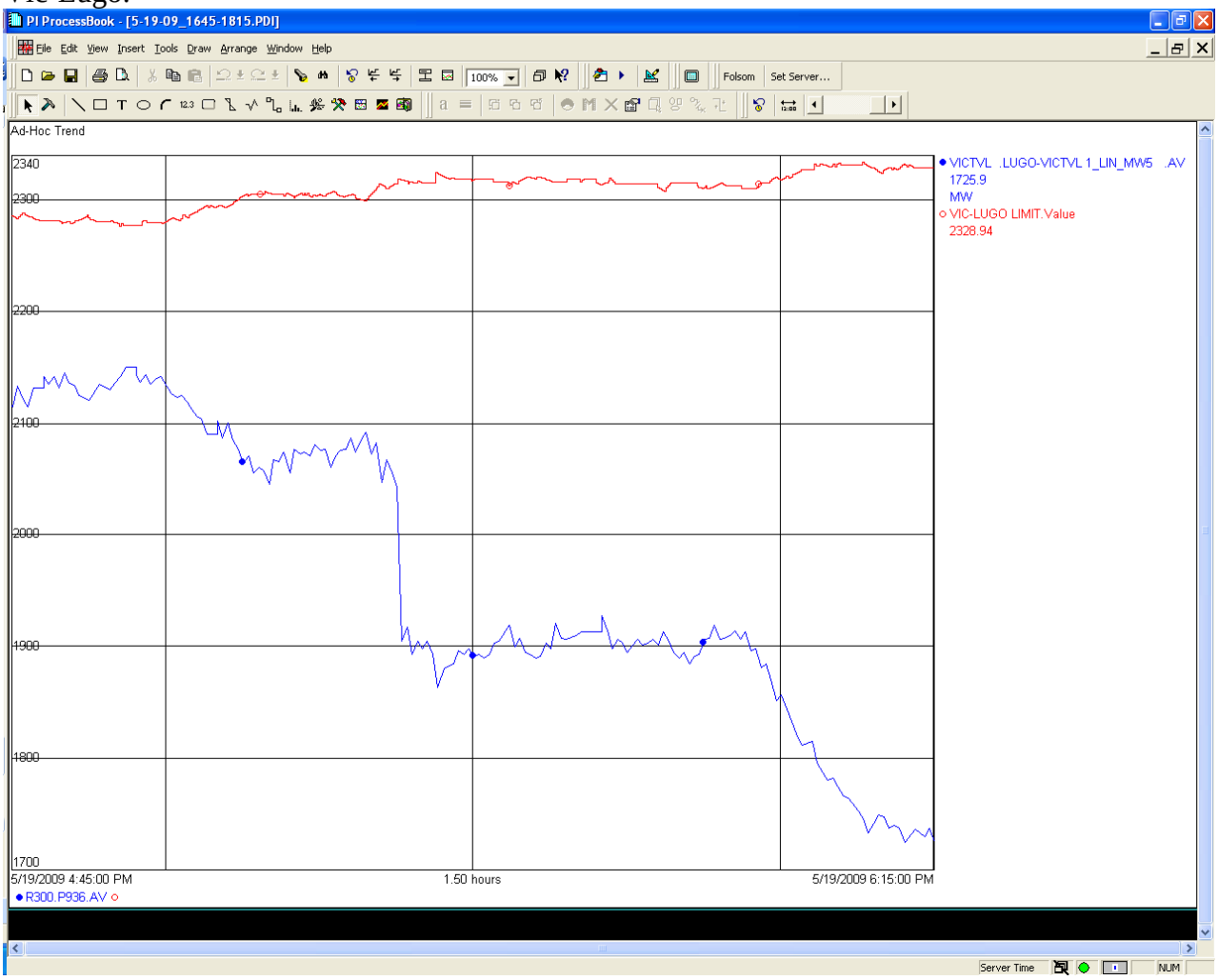


Figure 10: Victorville-Lugo 1645-1815

Vic-Lugo:



3. Conclusion:

The constraint conditions leading to the high prices on May 19th were mainly the result of higher than expected flow during significant maintenance work affecting the flow limits on several transmission interfaces feeding Southern California as well as unanticipated events affecting the schedules on PDCI.

While the constrained conditions on May 19 reflected the actual condition, following are actions that have been taken or are being considered to improve performance during constrained condition like those of May 19th:

- Previous day Load Distribution Factors may not be sufficiently accurate when weather patterns change over large area
  - LDFs in Real-Time are now using previous hour LDF from Library instead of previous days - complete
  - Load will be distributed adjusted from updated zonal load forecast before distributing to PNodes – complete
  - Day-Ahead Market LDFs should reflect similar weather patterns – Under consideration

- Limit Bias Practices
  - Review and refinement of practice is under review
  - Smooth out and more gradually apply changes to limit adjustments – in progress.
  - Recognize transmission constraint may not have to be fully resolved in 5 minute interval

- Improve use and access to ramping capability from resources
  - Access operating reserve for short-term imbalance events – under consideration. The status of NERC BAL-002 may have impact if Spin and Non-Spin can be dispatched except for a contingency event.
  - Recognize role of regulation capacity in meeting short-term imbalance energy needs and that all imbalance change need to be resolved in 5 minutes – under consideration