Residual Supply Metrics: Preliminary Methodology and Results

Draft Whitepaper Prepared for October 15, 2009 MSC Meeting

Department of Market Monitoring
October 13, 2009

Overview

The Residual Supply Index (RSI) is a commonly used measure of market competitiveness. A version of this test – referred to as the Three Pivotal Supplier (TPS) test -- is used by at least one other ISO (PJM) to assess the competitiveness of transmission constraints on a constraint-by-constraint basis in order to determine whether bid mitigation is triggered. The California ISO incorporates this general approach in its Competitive Path Assessment (CPA) methodology to determine which constraints are represented as *competitive* vs. *non-competitive* in the ISO's Local Market Power Mitigation (LMPM) procedures. However, the ISO's CPA methodology incorporates several key differences from PJM's TPS test: (1) while the ISO CPA analysis is performed on a annual or seasonal basis based on market scenarios, PJM applies the TPS test based on an hourly and even 5-minute basis based on actual market data; and (2) the PJM TPS test is applied to each individual constraint (in isolation), while the ISO's CPA is applied to all candidate constraints in the network simultaneously.[1]

While the Department of Market Monitoring (DMM) believes that the CPA methodology provides a sound basis for assessing the competitiveness of constraints, DMM believes that metrics based on the RSI can provide valuable additional information on the competitiveness of different constraints under a wide range of actual market conditions. For example, one of the advantages of the RSI is that it can be automatically calculated for any hour that congestion is observed based on market data (bid and schedules) and unit shift factors. Such results can be compared to results derived from the CPA studies used to assess the potential "false positives" or "false negatives" under the CPA approach, and to identify additional constraints and combination of residual suppliers that might be included in future CPA studies.

DMM has performed preliminary analysis of the competitiveness of various constraints using the RSI based on actual market conditions over the first five months of the ISO's new nodal market design, and believes it will be useful to discuss this methodology and preliminary results with the ISO's Market Surveillance Committee (MSC) to get their review and feedback on this approach. DMM also believes that these results may be useful information for the MSC to consider as part of a review of the CPA methodology that the Federal Energy Regulatory Commission (FERC) has directed the MSC to perform and file with the Commission within the first 12 months of the ISO's new nodal market design. Thus, this report and preliminary results have been prepared for the MSC and will be presented and discussed at the October 15, 2009 meeting of the MSC.

[1] See pp. 5-9 of *Competitive Path Assessment for MRTU: Final Results for MRTU Go-Live*, February 2009, http://www.caiso.com/2365/23659ca314f0.pdf

Methodology

The following example compares two different approaches for applying the Residual Supply Index (or Pivotal Supplier Test) to a constraint. In this example, there are three major suppliers (each with 100 MW of supply of effective counterflow on the constraint), plus 300 MW of potential effective counterflow on the constraint.[2] The total flow on the line during this time interval is 1,000 MW (which is equal to the constraints rated maximum capacity).

- **PJM Approach.** PJM refers to its test as the Three Pivotal Supplier Test. As we understand PJM's approach, they define the demand for congestion relief to be about 5% of the line's rated capacity. In this example, this would be about 50 MW. The incremental amount of effective supply available to meet this demand for congestion relief is then calculated (it is somewhat unclear what level of "base supply" PJM's uses for each unit as the point from which they measure the remaining "incremental supply" available to relieve congestion). In the example below, we have assumed that for purposes of calculating the RSI after-the-fact, this could be done based on the unit's actual dispatch level. As shown in Figure 1, this would result in a residual supply (after excluding the incremental supply of the three major suppliers) of 130 MW, or an RSI_3 of 2.6. Thus, the constraint would be deemed competitive under this PJM approach. PJM's approach also uses a *price screen*, which limits the bids considered in the pivotal supplier test to bids below a specific threshold.[3].

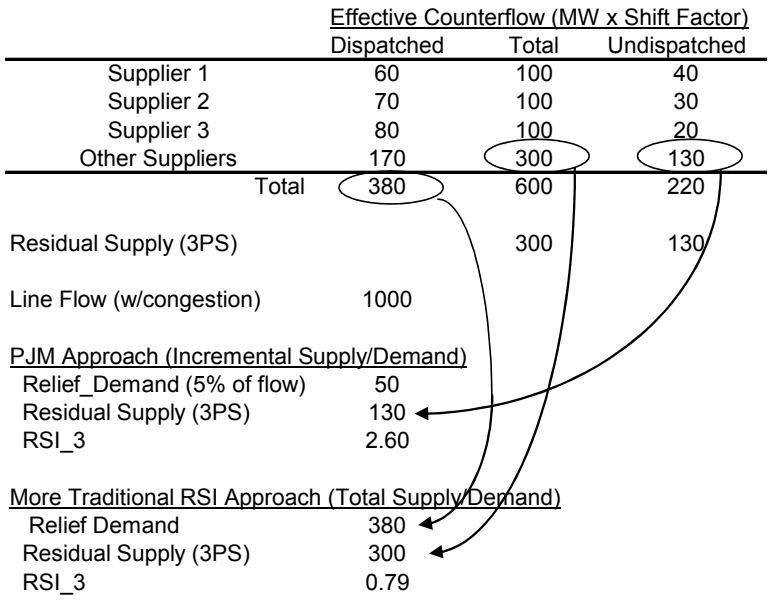
- **More Traditional RSI Approach.** A more traditional RSI or pivotal supplier approach is based on total supply and demand. In this example, this would be about 380 MW of counterflow, and a residual supply of 380 MW of total effective supply (after excluding the supply of the 3 major suppliers). As shown in Figure 1, this would result in a RSI_3 of only .76. However, in other cases, this RSI approach could result in a higher value than the "incremental" PJM approach. As shown in Figure 2, this can occur when residual suppliers (other than the three largest) account for a relatively large portion of "base flow" or scheduled generation, while the three largest suppliers account for a larger share of the unloaded supply that can relieve congestion.

---

[2] Effective counterflow calculated by multiplying maximum bid quantity from each resource with a negative shift factor relative to the constraint by the resource's shift factor. This number is then converted to a positive number. PJM excludes resources with shift factors < .03 while MISO excludes units with shift factors < .06 from this calculation on the grounds that these would typically be very expensive to re-dispatch in order to relieve congestion on the constraint.

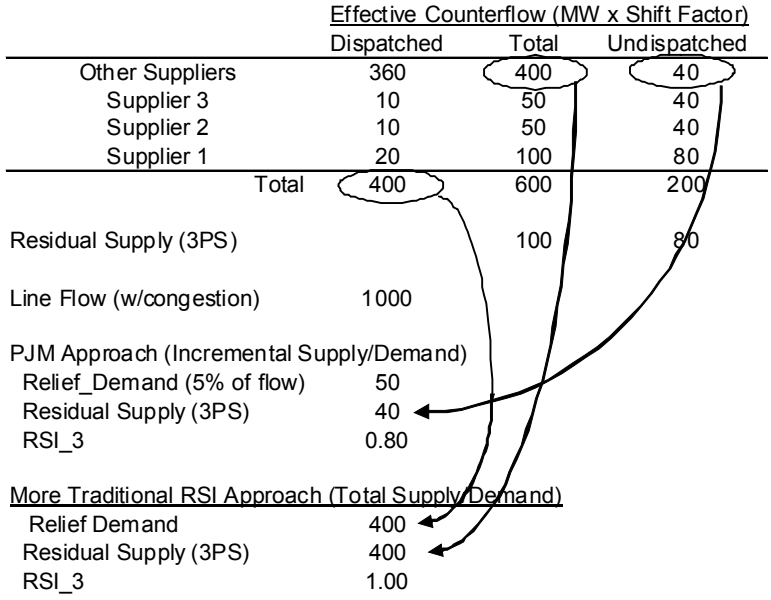
[3] Under PJM's approach, bids are only considered in the pivotal supplier test if their effective bid price (bid price x shift factor) is within 150 percent of the shadow price of the constraint based on cost-based offers. See pp. 15 and 25 of *Three Pivotal Supplier Test: Theory and Application*, August 20, 2007, http://www.monitoringanalytics.com/reports/Presentations/2007/20070820-tps-theory-application.pdf

Figure 1. RSI Example 1



	Effective Counterflow (MW x Shift Factor)		
	Dispatched	Total	Undispatched
Supplier 1	60	100	40
Supplier 2	70	100	30
Supplier 3	80	100	20
Other Suppliers	170	300	130
Total	380	600	220
Residual Supply (3PS)		300	130
Line Flow (w/congestion)	1000		
PJM Approach (Incremental Supply/Demand)			
Relief_Demand (5% of flow)	50		
Residual Supply (3PS)	130		
RSI_3	2.60		
More Traditional RSI Approach (Total Supply/Demand)			
Relief Demand	380		
Residual Supply (3PS)	300		
RSI_3	0.79		

Figure 2. RSI Example 2



	Effective Counterflow (MW x Shift Factor)		
	Dispatched	Total	Undispatched
Other Suppliers	360	400	40
Supplier 3	10	50	40
Supplier 2	10	50	40
Supplier 1	20	100	80
Total	400	600	200
Residual Supply (3PS)		100	80
Line Flow (w/congestion)	1000		
PJM Approach (Incremental Supply/Demand)			
Relief_Demand (5% of flow)	50		
Residual Supply (3PS)	40		
RSI_3	0.80		
More Traditional RSI Approach (Total Supply/Demand)			
Relief Demand	400		
Residual Supply (3PS)	400		
RSI_3	1.00		

DMM's initial assessment of these two approaches is that the more traditional RSI approach may be more appropriate for the IFM, since virtually all units can be committed/not committed in the IFM, and all energy scheduled in the IFM is settled at the IFM price. However, we believe that an "incremental approach" similar to that used by PJM might be more appropriate for the RTM in some cases. For example, we could base each units "base schedule" on its IFM schedule, and calculate its available incremental supply of counterflow in the RTM based on its remaining unscheduled capacity. This would also reflect the fact that if a supplier seeks to withhold energy already scheduled in the IFM to drive up RTM prices, they would need to pay back this higher price for the difference in their final dispatch and their IFM schedule.

Preliminary Results

The preliminary metrics in this report are based on the more tradition pivotal supplier test illustrated in Figures 1 and 2. The analysis covers all hours of congestion for each constraint during the first five months of the ISO's new market design. In some cases, the preliminary RSI analysis presented in Table 1 and Table 3 includes missing values for the RSI in the IFM or RTM for some constraints on which congestion occurred. These missing values results from a combination of factors:

- Congestion on some constraints is due to limited transmission capacity to transfer power out of areas with excessive generation, e.g. "gen pockets". In such cases, congestion is due to too much positive flow, instead of lack of counter flow. As a result, no RSIs based on the supply and demand of effective counter flow can be calculated.
- These initial calculations only include counter flow from generating resources with this ISO, and do not include any counter flow contributions from intertie resources. This is a potential refinement to this preliminary analysis.
- In some cases, shift factors for all constraints were not available for use in this analysis. Although DMM has access to data that can be used to calculate shift factor for each resource relative to each congested constraint, these data must be processed. Currently only shift factors from IFM have been used in this preliminary analysis. Thus, if a congestion only occur in the real-time market and is never binding in the IFM, the shift factors for this congestion are not retrieved; and therefore, no RSI is reported.

Non-Competitive Paths

Table 1 shows results of the RSI analysis for *non-competitive* paths. Table 2 shows additional summary statistics on the frequency of congestion in different phases of the ISO's markets (including pre-market runs upon which mitigation is triggered), total congestion costs, and average shadow prices. The preliminary analysis summarized in Table 1 show that:

- Constraints deemed as non-competitive generally have an average RSI less than 1, indicating a lack of competitiveness.

- Most of the constraints with an RSI greater than 1 were deemed to be non-competitive by default and were not assessed in the last CPA performed prior to the start of the ISO's new market since the frequency of congestion on these constraints was less than the minimum threshold used to determine which paths were examined in the CPA (500 hours).
- The RSI is generally lower in the RTM than in the IFM. This can be attributed primarily to the fact that in some resources bid into the IFM market are not bid into the RTM if not committed in the IFM and/or are non-quick start units that were not on-line (and therefore excluded from the RTM analysis). In addition, in the RTM constraints are sometimes biased below the limit used in the IFM, increasing the likelihood and/or magnitude of congestion and increasing the "demand" for counterflow in the RTM.
- In many cases, the RSI does not decrease or decreases only slightly as additional suppliers are excluded (i.e. RSI_1, RSI_2, RSI_3). This reflects the fact that there is often only one major supplier that owns or controls the capacity that can provide effective counterflow on a constraint.

Competitive Paths

Table 3 shows results of the RSI analysis for *competitive* paths, while Table 4 shows additional statistics summarizing congestion on these paths. As shown in Table 3, results of this analysis show that:

- Constraints deemed as competitive generally have an average RSI greater than 1, indicating they are competitive.
- The major constraints with an average RSI less than 1 were deemed to be competitive by default (Path 15 and Path 26). The relatively low average RSI – particularly in the RTM – for these paths may be in part due to biasing down of the limit on these paths in the RTM to manage loop flow and contingencies.
- Two smaller constraints in the Bay Area that were assessed in the CPA study and deemed to be competitive have an average RSI of less than 1[4]. DMM is performing further review of these results and these constraints.

Deleted: RSI of

Conclusions

As previously noted, results in this report are preliminary, and have been included in this report to facilitate review and discussion of the RSI methodology and these preliminary results with the MSC at its October 15, 2009 meeting. DMM will continue to review and refine its analysis, and looks forward to including results in future DMM reports and presentations, and discussing these with stakeholders.

[4] 33204_POTRERO _115_33206_BAYSHOR1_115_BR_1 _1 and 33206_BAYSHOR1_115_33208_MARTIN C_115_BR_1 _1

Table 1 and 3 Column Descriptions (RSI Results)

Row #		Row # (ranked by hours of congestion). Corresponds to same Row # in Tables 2 and 4.
CONSTRAINT		Constraint name from ISO market model
Cong. Hours		Number of hours congestion occurred (in pre-IFM MPM, IFM, pre-RTM MPM or RTM)
Avg. Flow		Average market flow during hours of congestion
IFM	IFM - Eff MW	Ratio of total effective supply of counterflow to total demand for counterflow.
	IFM - RSI_1	RSI with largest supplier removed.
	IFM - RSI_2	RSI with two suppliers removed.
	IFM - RSI_3	RSI with three largest suppliers removed.
RTM	RTM - Eff MW	Ratio of total effective supply of counterflow to total demand for counterflow.
	RTM - RSI_1	RSI with largest supplier removed.
	RTM - RSI_2	RSI with two suppliers removed.
	RTM - RSI_3	RSI with three largest suppliers removed.

Table 2 and 4 Column Descriptions (Congestion Summary)

Row #		Row # (ranked by hours of congestion). Corresponds to same Row # in Tables 2 and 4.
CONSTRAINT		Constraint name from ISO market model
Cong. Hours		Number of hours congestion occurred (in pre-IFM MPM, IFM, pre-RTM MPM or RTM)
Avg. Flow		Average market flow during hours of congestion
Cong. Hours	LMPM	Number of hours congestion occurred in pre-IFM MPM (All Constraints Run).
	IFM	Number of hours congestion occurred in IFM.
	LMPM	Number of hours congestion occurred in pre-RTM MPM (HASP All Constraints Run).
	RTD	Number of hours congestion occurred in RTM.
Total Cong. Cost	LMPM	Total congestion costs in pre-IFM MPM (All Constraints Run).
	IFM	Total congestion cost in IFM.
Avg. Shadow Price	LMPM	Avg. shadow price in pre-IFM MPM (All Constraints Run).
	IFM	Avg. shadow price in IFM.
	LMPM	Avg. shadow price in pre-RTM MPM (HASP All Constraints Run).
	RTD	Avg. shadow price in RTM.

Table 1. Summary of RSI Results - Non-Competitive Paths (April-August, 2009),

Row #	CONSTRAINT_NAME	Cong. Hours	Avg. Flow	IFM ---------->				RTM ---------->			
				Eff MW	RSI1	RSI2	RSI3	Eff MW	RSI1	RSI2	RSI3
1	24082_LCIENEGA_230_24074_LA FRESA_230_BR_1 _1	204	701	7.15	.17	.17	.17	1.47	.22	.21	.21
2	32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	188	56	1.03	1.02	1.01	1.00	1.00	1.00	.99	.99
3	30875_MC CALL _230_30880_HENTAP2 _230_BR_1 _1	136	380	5.20	4.77	4.68	4.63	2.87	2.37	2.33	2.31
4	30543_ROSSTAP1_230_30550_MORAGA _230_BR_1 _1	125	379	1.18	.48	.42	.37	1.01	.70	.65	.63
5	31482_PALERMO _115_32280_E.MRY J2_115_BR_1 _1	119	78	1.01	.96	.92	.91	1.00	.96	.92	.91
6	30250_CARIBOU _230_30261_BELDENTP_230_BR_1 _1	93	225	1.16	1.05	.95	.92	1.04	.95	.86	.83
7	VICTVL_BG	88	2,429	1.22	1.03	.95	.90	1.03	.84	.79	.75
8	30105_COTTNWD _230_30245_ROUND MT_230_BR_3 _1	79	257	1.09	.64	.60	.58	1.01	.69	.66	.65
9	LOSBANOSNORTH_BG	62	2,077	1.25	.86	.74	.67	1.06	.66	.61	.56
10	31482_PALERMO _115_31508_HONC JT3_115_BR_1 _1	51	80	1.01	.97	.93	.91	1.00	.99	.98	.97
11	T-165 TABLMT_RIOVACADX_NG_SUM	48	545	1.01	.99	.97	.95	1.00	.98	.96	.95
12	32290_OLIVH J1_115_32214_RIO OSO _115_BR_1 _1	40	95	5.73	5.52	5.52	5.52	1.12	1.03	1.03	1.03
13	32990_MARTINEZ_115_33014_ALHAMTP1_115_BR_1 _1	39	95	1.25	.96	.91	.90	1.00	.75	.68	.67
14	32228_PLACER _115_32236_FLINT J1_115_BR_1 _1	36	64	1.18	1.04	.99	.96	1.03	.95	.94	.92
15	32200_PEASE _115_31506_HONC JT1_115_BR_1 _1	36	86	1.25	1.23	1.23	1.22	1.05	1.04	1.04	1.03
16	31990_DAVIS _115_31962_WDLND_BM_115_BR_1 _1	32	119	1.15	1.06	1.03	1.00	1.02	.94	.92	.89
17	32228_PLACER _115_32239_FLINT J2_115_BR_2 _1	31	64	1.23	1.15	1.12	1.10	1.02	.94	.93	.92
18	LUGO_VINCENT_BG	29	3,150	1.75	1.39	1.28	1.18	1.13	.85	.75	.70
19	30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	27	1,892	1.13	1.04	1.02	1.00	1.03	.93	.91	.90
20	22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	26	174	3.07	3.03	3.03	3.03	1.21	1.21	1.21	1.21
21	32208_GLEAF TP_115_32214_RIO OSO _115_BR_1 _1	25	80	1.04	1.03	1.02	1.01	1.01	1.00	1.00	.99
22	33310_SANMATEO_115_33315_RAVENSWD_115_BR_1 _1	23	64	1.32	.79	.75	.75	1.01	.55	.35	.32
23	32231_HORSE J2_115_32235_NEWC J2 _115_BR_2 _1	18	64	1.29	1.24	1.21	1.18	1.02	.99	.97	.95
24	30550_MORAGA _230_30554_CASTROVL_230_BR_1 _1	16	318	1.41	.81	.46	.39	1.00	.58	.47	.41
25	30525_C.COSTA _230_30544_ROSSTAP2_230_BR_2 _1	12	329	1.30	.68	.65	.65	1.04	.49	.45	.45
26	32990_MARTINEZ_115_33016_ALHAMTP2_115_BR_1 _1	11	91	1.19	1.06	1.01	.98	1.00	.94	.92	.90
27	24156_VINCENT _500_24155_VINCENT _230_XF_1 _P	9	981	1.25	1.16	1.14	1.12				
28	24155_VINCENT _230_24401_ANTELOPE_230_BR_1 _1	9	477	1.36	1.16	1.12	1.10	1.02	.84	.82	.82
29	22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_80	9	591	1.20	1.19	1.18	1.18	1.00	.99	.99	.99
30	33010_SOBRANTE_115_30540_SOBRANTE_230_XF_1	7	375	1.13	1.04	1.03	1.03				
31	SOUTHLUGO_RV_BG	7	4,150	1.11	1.08	1.05	1.02	1.00	.97	.94	.92
32	99106_SAN-MAR1_230_99104_MAR-SAN1_230_BR_1 _3	6	251	1.00	1.00	1.00	1.00				
33	30060_MIDWAY _500_24156_VINCENT _500_BR_3 _2	4	1,497	1.12	1.09	1.06	1.03	1.00	.98	.95	.93
34	30055_GATES1 _500_30060_MIDWAY _500_BR_1 _3	4	1,883	1.55	1.35	1.28	1.25				
35	35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	2	94	1.48	.48	.42	.41				
36	34713_OGLE TAP_115_34784_CAWELO C_115_BR_1 _1	2	102	1.00	1.00	1.00	1.00				
37	30790_PANOCHE _230_30900_GATES _230_BR_1 _1	1	281	1.49	1.13	.83	.69				

Table 2. Summary of Congestion - Non-Competitive Paths (April-August, 2009)

Row #	CONSTRAINT_NAME	Cong. Hours	Avg. Flow	<-- Congested Hours -->				Total Cong Cost		<--- Avg. Shadow Price --->			
				LMPM	IFM	LMPM	RTD	LMPM	IFM	LMPM	IFM	LMPM	RTD
1	24082_LCIENEGA_230_24074_LA FRESA_230_BR_1 _1	204	701	169	62	27	13	$8,157,223	$492,720	$68	$11	$332	$215
2	32212_E.NICOLS_115_32214_RIO OSO _115_BR_1 _1	188	56	148	158	16	15	$3,026,653	$2,601,539	$363	$293	$482	$338
3	30875_MC CALL _230_30880_HENTAP2 _230_BR_1 _1	136	380	72	27	61	13	$418,726	$131,970	$15	$13	$26	$18
4	30543_ROSSTAP1_230_30550_MORAGA _230_BR_1 _1	125	379	47	47	50	60	$370,324	$438,419	$21	$25	$330	$619
5	31482_PALERMO _115_32280_E.MRY J2_115_BR_1 _1	119	78	84	100	10	4	$614,556	$595,574	$93	$76	$517	$663
6	30250_CARIBOU _230_30261_BELDENTP_230_BR_1 _1	93	225	87	5	17	17	$5,701,091	$197,263	$303	$178	$63	$78
7	VICTVL_BG	88	2,429	44	42	28	25	$922,002	$556,941	$9	$5	$336	$323
8	30105_COTTNWD _230_30245_ROUND MT_230_BR_3 _1	79	257	55	52	13	14	$2,696,786	$1,920,476	$196	$137	$334	$364
9	LOSBANOSNORTH_BG	62	2,077	14	24	32	19	$232,601	$860,728	$10	$17	$131	$64
10	31482_PALERMO _115_31508_HONC JT3_115_BR_1 _1	51	80	17	35	11	8	$175,269	$529,154	$121	$173	$104	$513
11	T-165 TABLMT_RIOVACADX_NG_SUM	48	545	48	48	36	2	$0	$0	$14	$23	-$6	$27
12	32290_OLIVH J1_115_32214_RIO OSO _115_BR_1 _1	40	95	8	3	18	22	$565,819	$163,105	$737	$570	$394	$388
13	32990_MARTINEZ_115_33014_ALHAMTP1_115_BR_1 _1	39	95	18	12	9	9	$94,838	$99,727	$55	$88	$299	$582
14	32228_PLACER _115_32236_FLINT J1_115_BR_1 _1	36	64	11	30	8	6	$28,857	$135,955	$41	$71	$500	$32
15	32200_PEASE _115_31506_HONC JT1_115_BR_1 _1	36	86	9	9	15	14	$66,470	$829,737	$86	$1,070	$720	$263
16	31990_DAVIS _115_31962_WDLND_BM_115_BR_1 _1	32	119	24	2	6	7	$2,324,436	$74,968	$452	$314	$492	$364
17	32228_PLACER _115_32239_FLINT J2_115_BR_2 _1	31	64	21	17	10	5	$57,572	$48,311	$43	$44	$594	$375
18	LUGO_VINCENT_BG	29	3,150		2	23	13		$3,794		$1	$7	$53
19	30005_ROUND MT_500_30015_TABLE MT_500_BR_1 _2	27	1,892	22	9	14	9	$697,874	$360,337	$17	$21	$30	$80
20	22192_DOUBLTTP_138_22300_FRIARS _138_BR_1 _1	26	174	11	8	14	14	$110,446	$10,502	$57	$8	$131	$157
21	32208_GLEAF TP_115_32214_RIO OSO _115_BR_1 _1	25	80	16	12	7	7	$362,002	$21,036	$300	$22	$416	$355
22	33310_SANMATEO_115_33315_RAVENSWD_115_BR_1 _1	23	64	9	1	10	13	$120,389	$1,528	$169	$24	$472	$500
23	32231_HORSE J2_115_32235_NEWC J2 _115_BR_2 _1	18	64	15	10	4	3	$40,299	$28,469	$42	$45	$584	$663
24	30550_MORAGA _230_30554_CASTROVL_230_BR_1 _1	16	318	7	8	7	5	$109,672	$93,708	$49	$37	$974	$614
25	30525_C.COSTA _230_30544_ROSSTAP2_230_BR_2 _1	12	329	9	10		2	$238,137	$687,139	$80	$209		$17
26	32990_MARTINEZ_115_33016_ALHAMTP2_115_BR_1 _1	11	91	7	8	1	3	$37,447	$107,790	$59	$148	$77	$35
27	24156_VINCENT _500_24155_VINCENT _230_XF_1 _P	9	981	4	7	2		$218,995	$79,600	$56	$12	$51	
28	24155_VINCENT _230_24401_ANTELOPE_230_BR_1 _1	9	477	1	1	8	2	$4,709	$1,229	$10	$3	$69	$35
29	22356_IMPRLVLY_230_22360_IMPRLVLY_500_XF_80	9	591	7	9		1	$54,340	$81,415	$13	$15		$500
30	33010_SOBRANTE_115_30540_SOBRANTE_230_XF_1	7	375	2	7			$32,938	$230,755	$44	$88		
31	SOUTHLUGO_RV_BG	7	4,150	2	4	4	5	$19,155	$272,784	$2	$16	$13	$500
32	99106_SAN-MAR1_230_99104_MAR-SAN1_230_BR_1 _3	6	251	5	1			$3,800	$591	$3	$2		
33	30060_MIDWAY _500_24156_VINCENT _500_BR_3 _2	4	1,497		2	1	1		$12,083		$4	$6	$966
34	30055_GATES1 _500_30060_MIDWAY _500_BR_1 _3	4	1,883		3	1			$38,942		$7	$0	
35	35122_NWARK EF_115_35350_AMES BS _115_BR_2 _1	2	94		1	1			$1,975		$21	$1,582	
36	34713_OGLE TAP_115_34784_CAWELO C_115_BR_1 _1	2	102	2	2			$23,679	$24,713	$116	$121		
37	30790_PANOCHE _230_30900_GATES _230_BR_1 _1	1	281		1				$2,739		$10		

Table 3. Summary of RSI Results- Competitive Paths (April-August, 2009),

Row #	CONSTRAINT_NAME	Cong. Hours	Avg. Flow	IFM ---------->				RTM ---------->			
				Eff MW	RSI1	RSI2	RSI3	Eff MW	RSI1	RSI2	RSI3
1	HUMBOLDT_BG	399	43	1.38	1.38	1.38	1.38	1.19	1.19	1.19	1.19
2	SDGE_CFEIMP_BG	322	2,325	2.29	1.87	1.85	1.84	1.09	1.09	1.08	1.08
3	PATH26_BG	307	1,643	1.32	1.24	1.18	1.15	1.02	.98	.96	.94
4	SDGEIMP_BG	132	2,139	2.46	2.30	2.24	2.21	1.09	1.08	1.07	1.07
5	33205_HNTRS PT_115_33208_MARTIN C_115_BR_3 _1	93	124	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	PATH15_BG	88	2,534	1.63	1.25	1.07	.98	1.10	.84	.75	.68
7	33206_BAYSHOR1_115_33208_MARTIN C_115_BR_1 _1	45	89	1.00	.75	.75	.75				
8	SSONGS_BG	24	1,520	1.89	1.81	1.74	1.74	1.07	1.06	1.06	1.06
9	31000_HUMBOLDT_115_31001_HMBLT TM_ 1.0_XF_1	11	42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	33204_POTRERO _115_33206_BAYSHOR1_115_BR_1 _1	2	87	1.00	.89	.89	.89				
11	IPPDCADLN_BG	738	557								
12	WSTWGMEAD_MSL	249	174								
13	IPP-IPPGEN_MSL	68	470								
14	33252_POTRERO3_20.0_33204_POTRERO _115_XF_G3	48	195								
15	IVALLYBANK_XFBG	26	760								
16	SUTTEROBANION_BG	19	525								
17	33207_BAYSHOR2_115_33208_MARTIN C_115_BR_2 _1	6	125								
18	ADLANTOSP_MSL	6	1,242								
19	MKTPCADLN_MSL	5	630								
20	FCORNER5_MSL	4	924								
21	33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	1	458								
22	33204_POTRERO _115_33207_BAYSHOR2_115_BR_2 _1	1	129								
23	NEWMELONP_BG	1	384								

Table 4. Summary of Congestion - Competitive Paths (April-August, 2009)

Row #	CONSTRAINT_NAME	Cong. Hours	Avg. Flow	<-- Congested Hours -->				Total Cong Cost		<--- Avg. Shadow Price --->			
				LMPM	IFM	LMPM	RTD	LMPM	IFM	LMPM	IFM	LMPM	RTD
1	HUMBOLDT_BG	399	43	121	129	212	172	$344,686	$283,483	$65	$52	$288	$222
2	SDGE_CFEIMP_BG	322	2,325	58	114	204	226	$515,015	$3,451,831	$4	$13	$20	$168
3	PATH26_BG	307	1,643	55	63	194	233	$776,328	$624,584	$10	$6	$23	$130
4	SDGEIMP_BG	132	2,139	57	66	49	54	$522,801	$501,882	$5	$4	$34	$559
5	33205_HNTRS PT_115_33208_MARTIN C_115_BR_3 _1	93	124	65	72	12	6	$245,548	$241,878	$31	$27	$38	$500
6	PATH15_BG	88	2,534	42	44	32	35	$956,100	$928,907	$9	$8	$56	$381
7	33206_BAYSHOR1_115_33208_MARTIN C_115_BR_1 _1	45	89	37	14		1	$117,976	$6,358	$26	$5		$500
8	SSONGS_BG	24	1,520	6	3	24	18	$32,273	$2,144	$4	$0	$7	$96
9	31000_HUMBOLDT_115_31001_HMBLT TM_ 1.0_XF_1	11	42	4	2	5	1	$89,375	$43,447	$500	$500	$500	$500
10	33204_POTRERO _115_33206_BAYSHOR1_115_BR_1 _1	2	87		1		1		$1,199		$14		$500
11	IPPDCADLN_BG	738	557	371	514	203	183	$904,991	$1,820,078	$5	$7	$44	$64
12	WSTWGMEAD_MSL	249	174	215	65	61	51	$194,744	$40,513	$5	$4	$167	$55
13	IPP-IPPGEN_MSL	68	470	16	16	1	54	$606,277	$158,243	$81	$21	$36	$87
14	33252_POTRERO3_20.0_33204_POTRERO _115_XF_G3	48	195	19	37	10	1	$27,940	$82,334	$8	$12	$157	$71
15	IVALLYBANK_XFBG	26	760			17	21					$12	$47
16	SUTTEROBANION_BG	19	525		2	11	8		$1,400		$1	$22	$309
17	33207_BAYSHOR2_115_33208_MARTIN C_115_BR_2 _1	6	125	3	3	1	1	$3,290	$3,335	$9	$9	$18	$500
18	ADLANTOSP_MSL	6	1,242	6				$7,155		$1			
19	MKTPCADLN_MSL	5	630	4		1		$2,877		$1		$250	
20	FCORNER5_MSL	4	924			3	1					$97	$53
21	33310_SANMATEO_115_30700_SANMATEO_230_XF_7 _S	1	458			1						$47	
22	33204_POTRERO _115_33207_BAYSHOR2_115_BR_2 _1	1	129				1						$500
23	NEWMELONP_BG	1	384				1						$0