California Independent
System Operator Corporation

LMP Study Update

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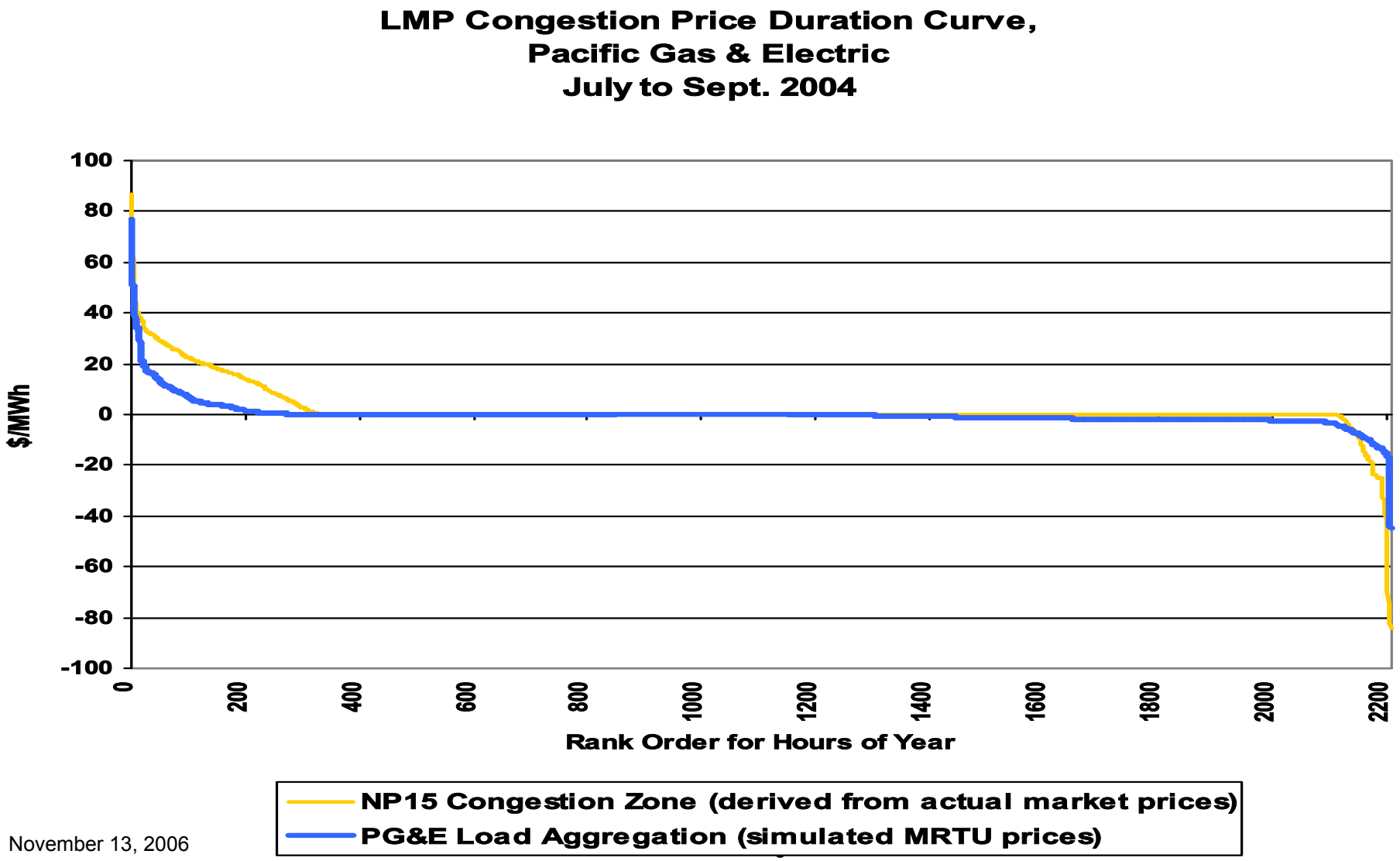
Overview of Presentation

- **Overview of Summer 2004 LMP Study Results**
- **CRR Financial Analysis**
- **Integration of Local Market Power Mitigation in LMP Study**
- **Other upcoming change:**
  - LMP Study will reflect treatment of SMUD, WAPA, MID, and TID as an "Adjacent Control Area"
- **Desired outcomes:**
  - Informational presentation
  - MSC feedback on upcoming study topics

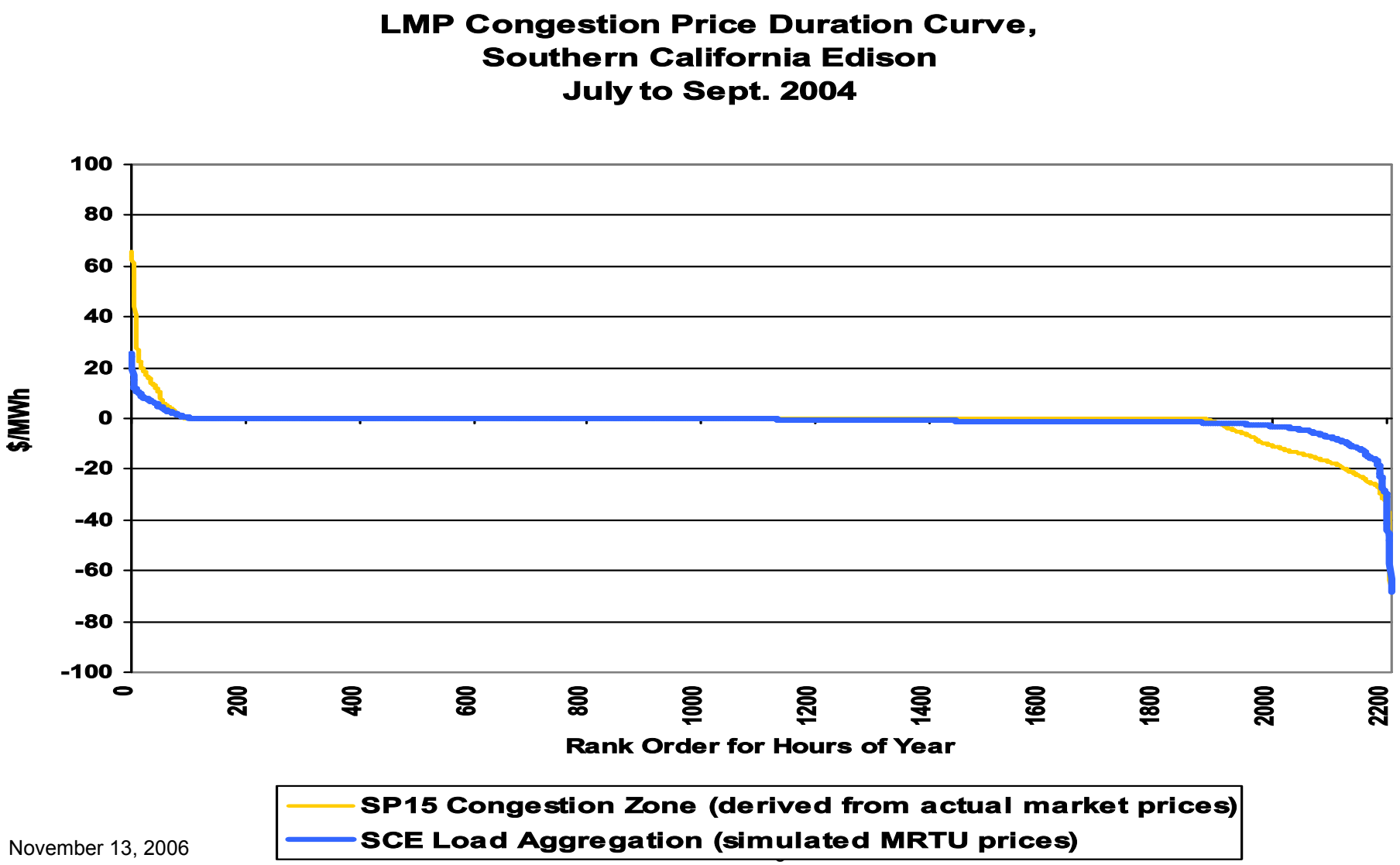
Overview of Summer 2004 LMP Study Results

- **Overall results of LMP simulations have been consistent with previous reports:**
  - LMP prices within major zones are generally very similar during most hours. However, during hours of high loads, congestion causes price differences within major zones.
  - The study produces very few high prices, and the frequency and magnitude of notable price differences within local load zones are broadly consistent with congestion costs in the CAISO's current real-time market.
  - Within local load zones, significant zonal price variations can occur in specific hours, but typically lasts only a few hours or less.
  - Exception is congestion at Miguel substation in San Diego

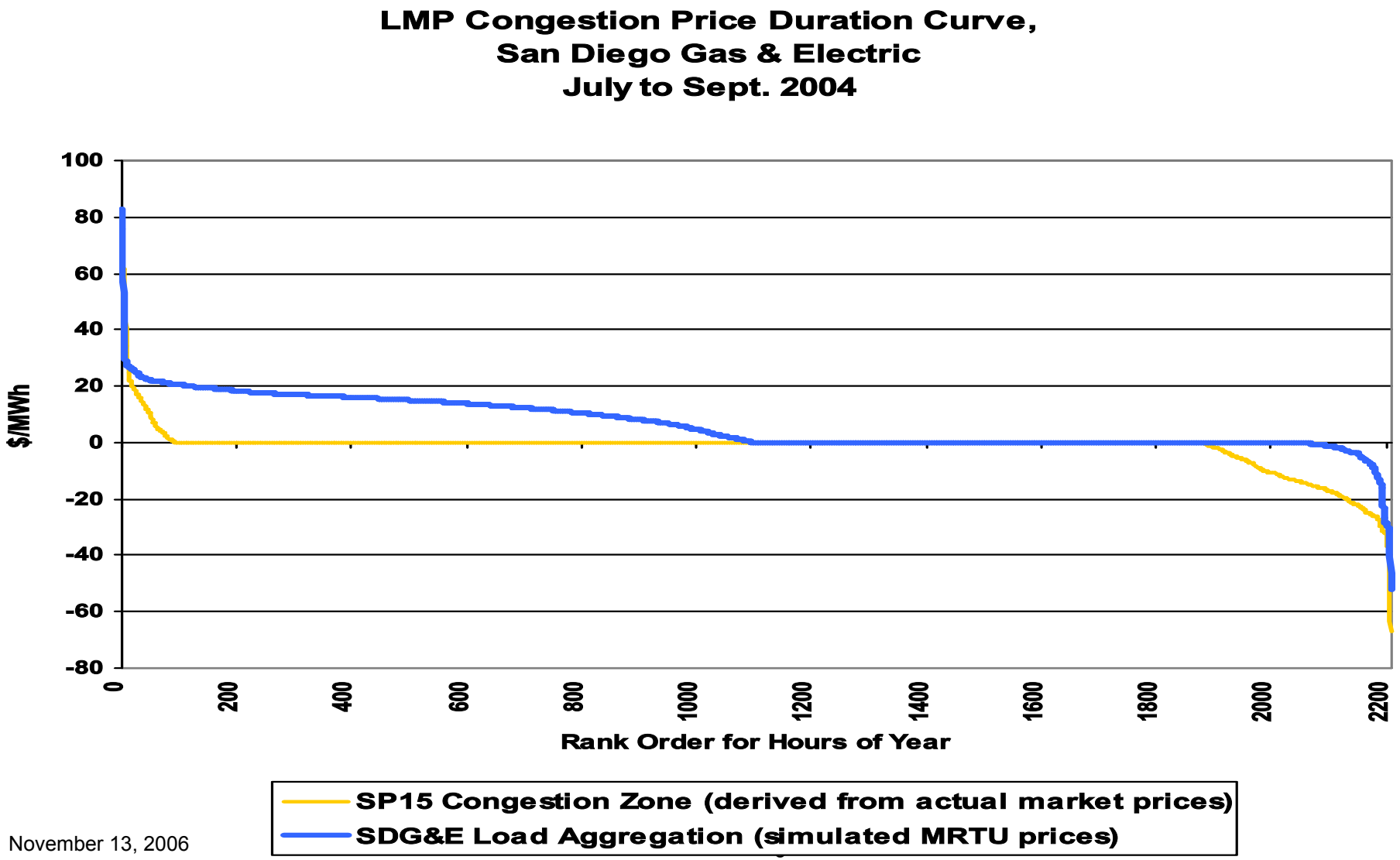
LMP Trend, PG&E



LMP Trend, SCE



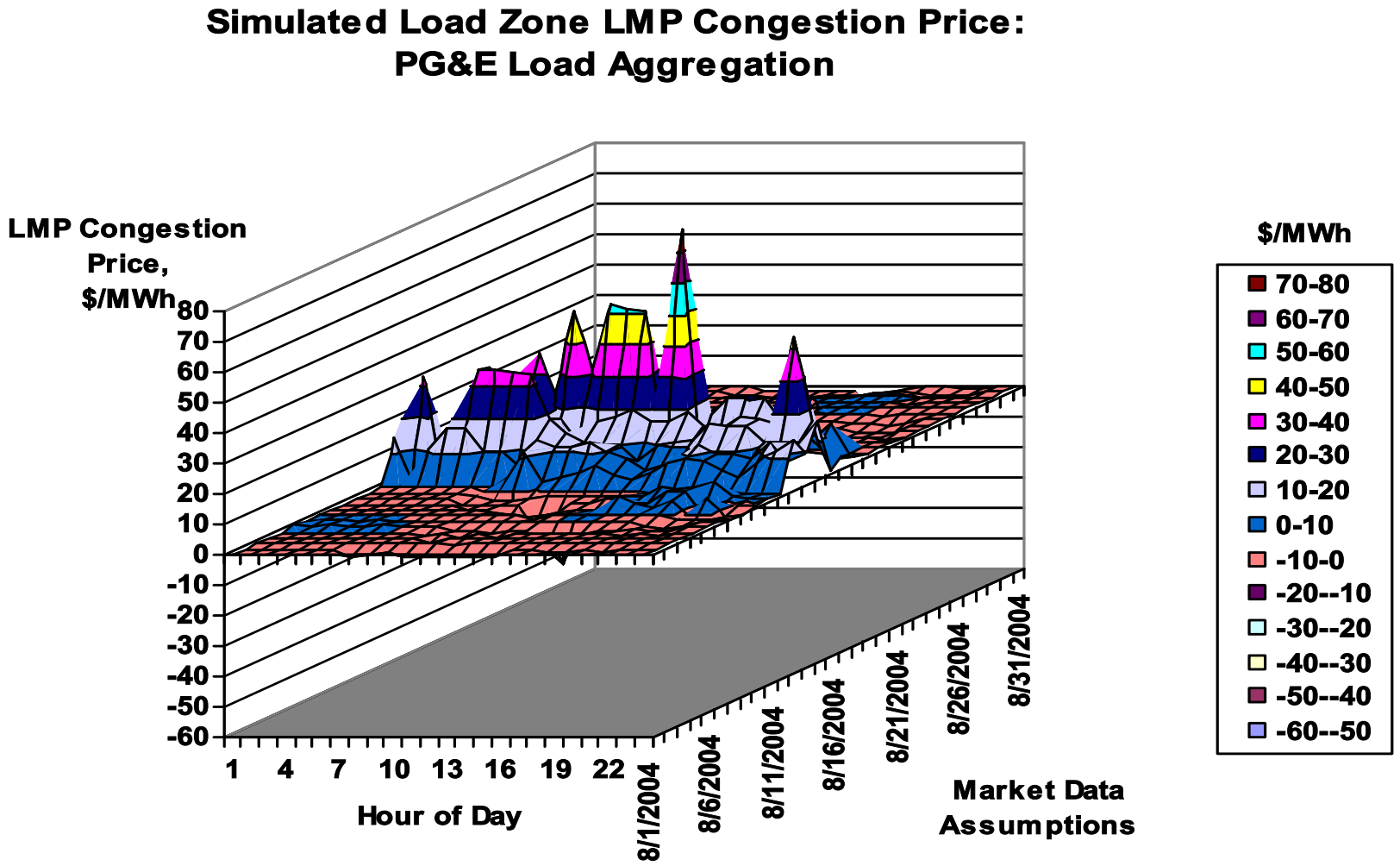
LMP Trend, SDG&E



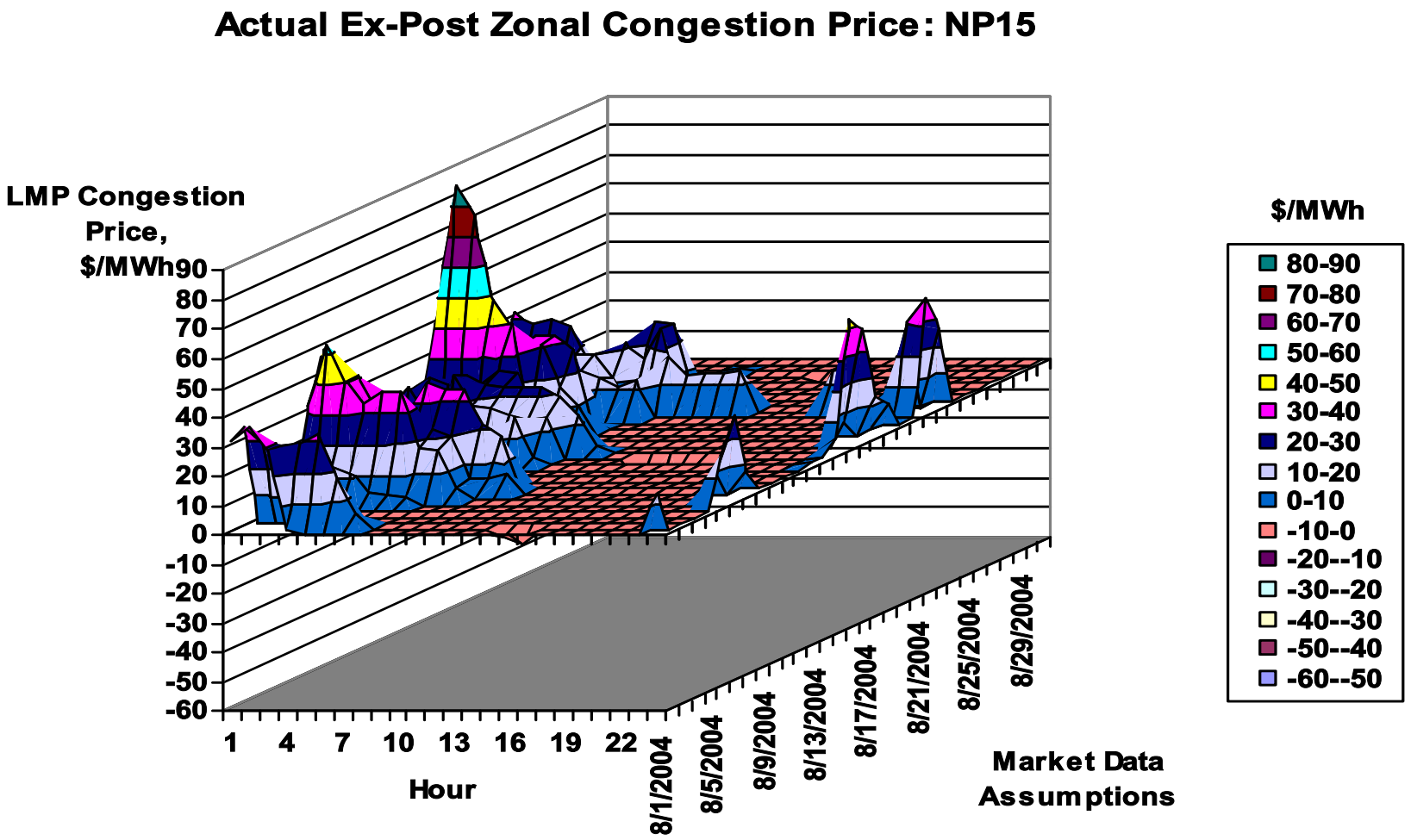
August 2004 Conditions

- **Although the total hours of congestion in the Northern and Southern California are similar in the LMP simulation and the actual zonal dispatch, the magnitude of congestion is less in LMP Study results due to OPF dispatch.**
- **Results for August 2004 found significant differences between the specific hours of congestion between Northern and Southern California, between actual zonal market results and the simulation results. Significant nighttime congestion costs on Path 15 occurred in actual operations, but the LMP simulation daytime congestion instead.**
- **Detailed examination showed that significant nighttime Path 15 capacity remained available in real-time, but contingency analysis revealed that lower operating limits should have been recognized during the day.**

August 2004 Conditions, LMP Study



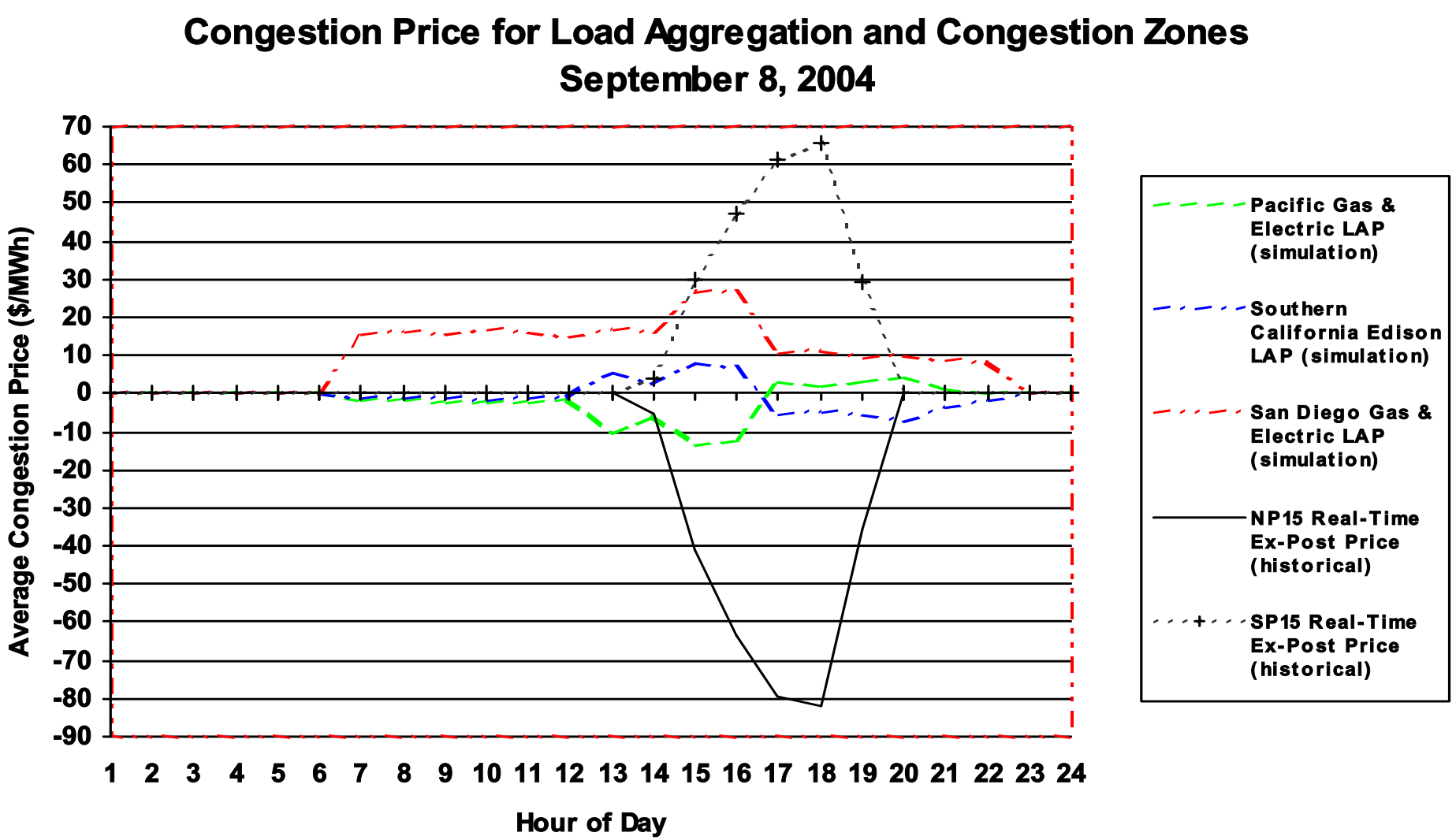
August 2004 Condition, Historical Market



September 8, 2004, Case Study

- 2004 CAISO peak occurred on September 8, 2004.
- With hot weather throughout CAISO, all-time record set at 45,597 MW. Between 3 and 6 PM, the real-time price was $165 to $175/MWh, set by a high-cost gas turbine in SP15.
- Real time in-sequence dispatch during this period averaged 1,218 MW, to meet high loads and to counter out-of-sequence decremental dispatches for Miguel congestion and other reasons. Available transmission was fully loaded in forward markets on key import paths.
- In similar conditions on Sept. 10, due to decremental dispatches for intra-zonal congestion in Southern California, CAISO had less than 100 MW of available capacity to spare.
- In LMP Study results, several intra-zonal constraints were binding, but optimized unit commitment allowed more capacity to remain available, resulting in lower market prices. Demonstrates benefit of Residual Unit Commitment.

September 8, 2004, Results



CRR Financial Analysis

- **CAISO published CRR Study 2 in August 2005**
  - Included financial analysis of CRRs for CAISO system and individual LSEs, as well as evaluation of alternative CRR market designs
- **CAISO is currently conducting CRR Dry Run**
  - Expected completion in early 2007
- **CAISO will calculate financial analysis for CRR Dry Run results**
  - Analysis will use LMP Study results to compare CRR payments to LSEs' congestion costs computed using
    1. CRR Study 2 methodology, and
    2. Historical market schedules

Scenarios for Congestion Cost

- **CRR Study 2 Methodology**
  - Assumes that LSEs have requested CRR portfolios that reflect future scheduling patterns
- **Historical Market Schedules**
  - Recognizes that hourly schedules can vary from "typical" portfolios
- **Each method has advantages, since future LSE portfolios might not be the same as in the past.**
- **The next several slides illustrate the calculation methods**

Congestion Rent Using Actual Schedules: Summary of Methodology

- **Foundation of this calculation is historical final Hour Ahead (HA) schedules. Real-Time balancing uses weighted LMP for CAISO, from LMP Study data**
  - Use today's HA schedules to closely resemble the Real-Time (RT) system operating conditions. (In MRTU, forward scheduling is in Day-Ahead Market.)
  - Today's Congestion Zones become MRTU Trading Hubs, and Demand Zones are aggregated into Load Aggregation Points (LAPs)
- **Example is adapted from historic data for a Load Serving Entity (LSE) in Southern California**

Congestion Rent Using Actual Schedules: Forward Market Scheduling Example

- **Sinks can be Load, Inter-SC Trades, or export on interties**
  - Scheduled Load: 100 MW at SCE LAP
  - Inter-SC Trade to other SCs: 1 MW at SP15 Trading Hub
- **Sources can be Generation, Inter-SC Trades, or import on interties**
  - Import: Total of 75 MW
    - 60 MW at PVERDE_5_DEVERS
    - 15 MW at SYLMAR_2_NOB
  - Inter-SC Trade from other SCs: 26 MW at SP15 Hub
- **This LSE has ETCs to cover part of its portfolio**
  - PVERDE_5_DEVERS to Load: 30 MW
  - SYLMAR_2_NOB to Load: 10 MW
- **LSE has been allocated CRRs to cover additional Load**
  - PVERDE_5_DEVERS to SCE LAP: 30 MW
  - SP15 Hub to SCE LAP: 20 MW

Congestion Rent Using Actual Schedules: RT Energy Market Example

- **Final HA Schedule is balanced for this LSE, but assume RT Load exceeds HA Schedule**
  - RT Load = 110 MW
  - Excess RT Load is bought from CAISO Market. Source could be Dispatch of Generation or deviations by either Generation or Load, so RT Supply is priced at weighted average of Generation and Load LMPs
- **Congestion occurs from PVERDE_5_DEVERS to SP15, and on Path 26, which affects LMPs**
- **Like LMP Study, Settlement is limited to values for a single market (Real-Time)**

Congestion Rent Using Actual Schedules: Results

	Location	MW 'Usage	ETC Coverage (MW)	Subject to Congestion (MW)	CRR Coverage (MW)	Congestion LMP ($/MWh)	Congestion Rent ($)
Sinks							
HA Load	SCE LAP/Load Point	100	40	60	50	2	120
Trade	SP15 Hub	1		1		1	1
RT Load	SCE LAP	10		10		2	20
Total cost							141
Sources							
Import	PVERDE_5_DEVERS	60	30	30	30	-1	-30
Import	SYLMAR_2_NOB	15	10	5	0	1	5
Trade	SP15 Hub	26		26	20	1	26
RT Supply		10		10		-1	-10
Total credit							-9
Total congestion cost							
HA							120
RT							30

Congestion Rent Using Actual Schedules: Summary of Results

- **LSE has partial coverage by ETCs, which "perfect hedge" exempts from congestion charges**
- **Congestion charges to remaining Load = $141, congestion payment to sources = $-9**
  - For RT deviation above HA Schedule, LSE buys Energy at total LMP cost for a system-wide market resource, and the congestion LMP component is treated as a source
- **Congestion cost = $120 in forward market + $30 for RT supply = $150**
- **LSE receives CRR revenue that partially offsets congestion cost**
  - PVERDE_5_DEVERS to SCE LAP: 30 MWh * $3/MWh = $90
  - SP15 Trading Hub to SCE LAP: 20 MWh * $1/MWh = $20

Congestion Rent Using CRR Study 2 Method: Summary of Methodology

- **CRR Study 2 methodology, designed by LECG, assumes that LSEs request CRRs from their expected generation sources to their expected load areas.**
- **Any additional load above their quantity of allocated CRRs will be assumed to be met at the LAP price where their load is scheduled.**
  - Thus, no congestion charges for this usage.
  - Based on assumption that most transfer capability of grid is released as CRRs, and additional load must be served by local resources.
  - Note: When CRR Study 2 was published, CAISO was considering load-based definition of Trading Hubs

Congestion Rent Using CRR Study 2 Method: Scheduling Assumptions

- **Assumed portfolios are based on RT Load.**
- **CAISO will use HA Schedules to establish association with ETCs, to subtract load that is already covered by ETCs.**
- **For LSE in the previous example:**
  - Load subject to congestion charges = 110 MW of Load – 40 MW of ETCs = 70 MW
  - LSE holds 50 MW of CRRs
    - Assumed to be met by Generation at CRR sources, in order of increasing congestion cost, until all Load is served or all CRRs have been used.
  - Remaining Load = 70 – 50 MW = 20 MW, assumed to be served by local generation at the LAP, and subject to the LAP price. Thus, $0 congestion cost for this Load.

Congestion Rent Using CRR Study 2 Method: Summary of Results

- **Congestion Rent =**
  (LMP_{Sink} ($/MWh) – LMP_{Source} ($/MWh)) * Usage Quantity (MWh)
- **CRR Revenue =**
  (LMP_{Sink} ($/MWh) – LMP_{Source} ($/MWh)) * CRR Quantity (MWh)
- **If usage quantity exceeds CRR quantity, LSE's CRRs will be used to serve LSE's Load. Supply capacity is covered by CRRs, and excess Load is assumed to be served by Supply at the LAP.**
  - In this case, LSE is perfectly hedged, and CRR revenue offsets congestion charges.

CRR Financial Analysis: Future Direction

- **Analysis will use CRR Dry Run results, to be available in early 2007.**
- **Any MSC feedback on methodology?**

Integration of Local Market Power Mitigation in LMP Study

- **With implementation of MRTU Phase 1B, bids used in LMP Study no longer include results of System Market Power Mitigation (MPM). MRTU's 2007 implementation will use Local MPM, not System MPM.**
- **LMP Study report on December 2004 conditions will include a case study of congestion at Miguel substation in San Diego**
  - Extensive Miguel congestion occurred in this month.
  - Case study will use Residual Supply Index function in PLEXOS to infer potential bid price mark-up, and demonstrate how Local MPM (LMPM) would apply.
  - Purpose is to demonstrate LMPM, not make determinations about whether exercise of local market power occurred.

Construction of Case Study

- **Residual Supply Analysis has been used by CAISO as a model of strategic bidding, in which concentration of generation ownership allows pivotal generation owners to increase bid prices in times of capacity shortage.**
- **Development of Residual Supply Index (RSI) is explained in CAISO's Transmission Economic Assessment Methodology (TEAM) report. Case study in LMP Study will use RSI parameters from the TEAM report, only for San Diego area.**
- **So the details can be presented, case study will use heat rates from London Economics grid planning report, on CAISO web site.**

Case Study Example

- **December 17, 2004, has roughly the average amount of Miguel congestion among days in December 2004. Miguel congestion occurs in all 24 hours of this day, as well as several other days.**
- **In Hour 12, Miguel constraint's shadow price is $84.81/MWh in SCOPE outputs (AC OPF). Concentration of generation ownership in San Diego (e.g., AES, CalPeak, Duke, Dynegy, smaller owners, and resources under SDG&E control) yields:**
  - Non-utility generation is 87.7% of total in area.
  - Bid cost mark-up is 60%, using PLEXOS formulation of RSI.
  - Results presented here are preliminary. Matching PLEXOS's LMPs from DC OPF, with SCOPE's LMPs from AC OPF, may change specific numbers.

Case Study Example (2)

- To apply LMPM for LMP Study results, six San Diego area generators have increased output when (1) all transmission constraints within CAISO are enforced, compared to (2) enforcing only intertie constraints and Paths 15 and 26.
- For these generators, the bid segments that have increased dispatch, when all constraints are enforced, will be replaced with existing Reference Prices that applied on December 17, 2004.
- LMP Results will be compared with and without LMPM.

Integration of LMPM in LMP Study: Future Direction

- **Plan is to use existing MPM reference bids to illustrate impact of LMPM bid modifications.**
  - Given that some months of model runs are already underway, this would occur starting with Summer 2005 conditions.
- **Issues such as construction of reference bids for MRTU have been complex. Analysis of these issues is probably beyond the scope of the LMP Study.**
- **Study could further explore Residual Unit Commitment, but probably not fruitful because only a single (real-time) market can be modeled.**
- **Any MSC feedback on methodology?**