Transmission Expansion and Mitigation of Market Power

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Economic Evaluation of Transmission Expansion
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Presentation Outline

- Importance of considering strategic bidding in transmission benefit calculations
- Approaches to modeling strategic bidding
- Potential benefits
- Case Study of Path 26 Expansion
- Impact of generation contracts on strategic bidding

Transmission Project Benefits Analysis – Traditional Production Cost Savings Approach

- Multi-area production simulation model to estimate regional marginal costs (fuel plus variable O&M costs)
- Zonal transmission models, with aggregations of buses into zones and multiple circuits into single paths, flow based on contract path
- No feedback between transmission expansion and power plants construction
- Regional marginal costs as equal to regional prices (ignoring market power issues and the differences between marginal costs and bid prices)
- The benefit for each megawatt hour (MWh) of import based on marginal cost differential between importing and exporting regions
- Sensitivity analysis to evaluate uncertainties of fuel prices, load forecasts, hydro electricity production. Probabilities associated with extreme events usually not considered

Factors To Be Considered In A Restructured Wholesale Market

- Unbundled decision making for generation and transmission expansion
- Network model critical since a number of factors can create congestion including scheduling practices and location of new generation rules do not require "deliverability" to load centers
- Actual market prices are not the same as marginal production cost and bidding strategies of power suppliers have significant impact on power prices and their volatility
- Changing regional power transfer patterns – unpredictable market behavior
- Transmission upgrades have significant insurance value against extreme events and extreme system conditions.
- Need more complex models to take into account bidding strategies (market power), the expansion and location of new merchant power plants, volatility and uncertainty factors, and accurate representation of the network system

Valuing Transmission Under Restructured Wholesale Markets

- In wholesale markets, price differences are sources of value of transmission network. Thus transmission expansion should have bigger value than in vertically integrated regime because price differences in restructured markets can be orders of magnitude larger.
- Transmission expansion as solution to local market power problem by expanding number of suppliers than can compete to supply energy at any location and by limiting location price differences due to the exercise of local market power.
- Transmission upgrades have significant insurance value against extreme events and extreme system conditions.

Major Challenges to Valuing Upgrades in New Environment

- How do strategic suppliers bid both before and after the transmission upgrade?
- What are the appropriate measures of transmission expansion benefits to different market participants?
- What evaluation criteria should be chosen? Whose benefit should be included in the evaluation. Does it differ if economic-driven transmission project is for both private investment and regulated investment?
- How should the ISO evaluate an economic-driven transmission upgrade project?

Private vs. Regulated Investment Under Restructured Wholesale Markets

- Private Investment: Does not seek cost recovery from electricity customer rate base. Cost is recovered through receiving FTR/CRR on the increased transmission capacity.
- Regulated Investment: Ratepayer funded transmission project including private project with regulated cost recovery arrangement.
- The distinction between private and regulated investment is important because it determines whose benefit to be included in project evaluation.
- TEAM focus is on regulated investment. A project is recommended if it benefits the ISO ratepayers or participants in aggregate.
- TEAM is general enough that any market participant can use this methodology to evaluate the effectiveness of its project. Does not preclude private investment.

Extensive Public Process Used to Develop TEAM

- ✓ In Feb. 2003, CAISO filed general blueprint of economic methodology and held a public workshop March 14, 2003 to fully review methods.
- ✓ In Dec. 2003, CPUC ALJ requested full implementation of methodology to be demonstrated using network model.
- ✓ In 2004 CAISO held 3 Public Workshops, 12 technical calls and solicited input from Market Surveillance Committee (MSC)
- Filed TEAM with CPUC on June 2
- Hearing to occur summer/fall 2004

Modeling Strategic Bidding

- Modeling strategic bidding is difficult
  - *Ad hoc* approach: fix bid adders
  - Game theoretical approach
    - Cournot-Nash game (physical withholding)
    - Supply function equilibrium (economic withholding)
    - These methods are difficult to implement in a complex network model
  - Empirical approach
    - Regression relates price-cost mark-up with Residual Supply Index
    - Can be viewed as a dynamic bid adder approach

An Empirical Approach to Model Strategic Bidding

1. Develop historical relationship (regression) between price-cost markups and certain system conditions.
2. Use the regression results to predict bid-cost markups under future system conditions.
3. Apply the bid-cost markups to the supply bids and run the model to determine dispatch and market clearing prices.

- Note:
  - Historical Price-Cost Markups are based on the difference between actual zonal market prices and estimated competitive prices.
  - Bid-Cost Markups are estimated and used prospectively in the transmission study. Bid-Cost Markups reflect the difference between the variable cost of a generating unit and a market-based bid.

Price-Cost Markup Regression

- Estimate relationship between price-cost markups (PMU) and system conditions
  - Using hourly data covering Nov-99 to Oct-00 and 2003.
  - The price-cost markup (PMU) is expressed as the Lerner Index.
  - Lerner Index at region ***i*** and hour ***t*** is:

    $PMU_{it}=(P_{it}-C_{it})/P_{it}$

    where P_{it} = Actual price in region *i* and hour *t*

    C_{it} = Estimated competitive price in region *i* and hour *t*
  - System conditions are represented by several key variables (e.g., RSI, % of Un-hedged load, etc.)

Residual Supply Index (RSI)

- A Residual Supply Index provides a good measure on the extent to which the largest supplier in the market is "pivotal" to meeting demand.

$$RSI = \frac{\text{(Total Supply – Largest Supplier's Supply)}}{\text{Total Demand}}$$

- Total Supply = Total Available Capacity + Import
- Largest Supplier's Supply = (Available Capacity - Long-Term-Contract Amount) of the Largest Supplier
- An RSI value less than 1 indicates the largest supplier is pivotal in meeting demand, and in the CAISO markets, RSI values less than 1.2 have generally been associated with market prices in excess of estimated competitive levels.
- RSI can capture the impact of transmission upgrade on supply/demand balance, as well as long-term contract's impact.

% of Load Un-hedged

- % of Load Un-hedged provides a good measure on the vulnerability of load.

  $$\%\ \text{of Load Un-hedged} = \frac{\text{Total Un-hedged Load}}{\text{Total Demand}}$$

- Total Un-hedged Load = Total Load – Utility-Owned Generation – Long Term Contract
- % of Un-hedged Load can capture the impact of long-term generation contract on supply/demand balance.

Price-Cost Markup Regression

- Regression parameters estimated for California
- Parameters for outside control areas could be based on backcast simulation and calibration (or regression analysis)
- Can be applied to zonal configuration of network models
- Can be applied with calibration to nodal network models

Regression Results

Dependent: Lerner Index		
Intercept	0.14 [11.08]	
RSI (gross RSI specification)	-0.53 [72.76]	-
Pct_load_unhedged	0.65 [70.98]	
Normalized Load (hourly load/annual average load)		
Dummy for Peak hour	0.086 [23.77]	
Dummy for Summer Months	0.15 [48.19]	[
R Squared	0.46	
Number of Observations	31333	

Bid Mark-up based on RSI

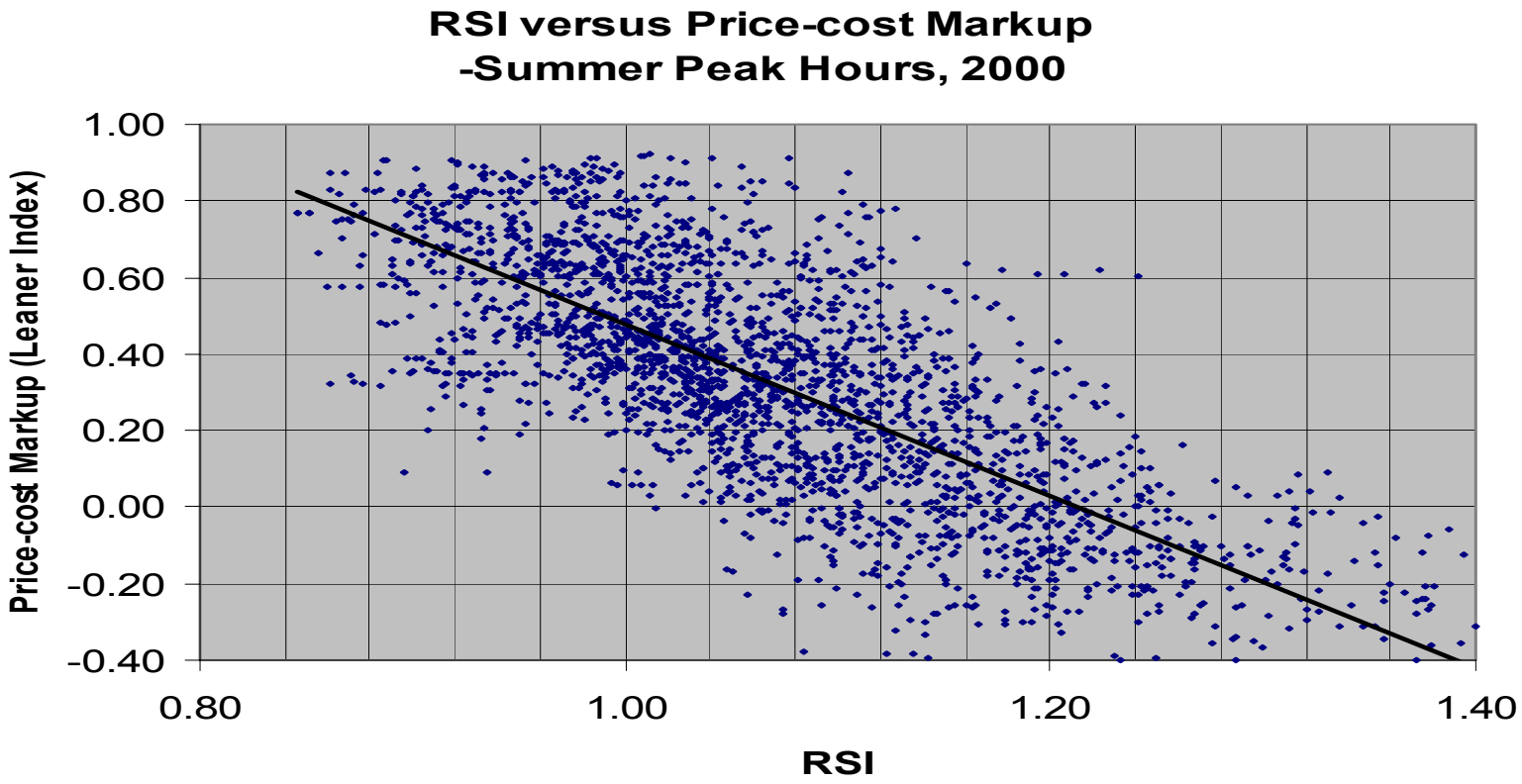
- RSI is residual supply index:

  (Supply in a zone - Largest supplier's capacity)

  / Demand in a Zone

- When RSI < 1.0, the largest supplier is pivotal in the zone and can demand very high prices
- Empirical analysis shows price-cost mark-up is highly correlated to RSI. Low RSI ==> High mark-up
- ISO has used this formula to project market competitiveness and evaluate benefits of transmission projects

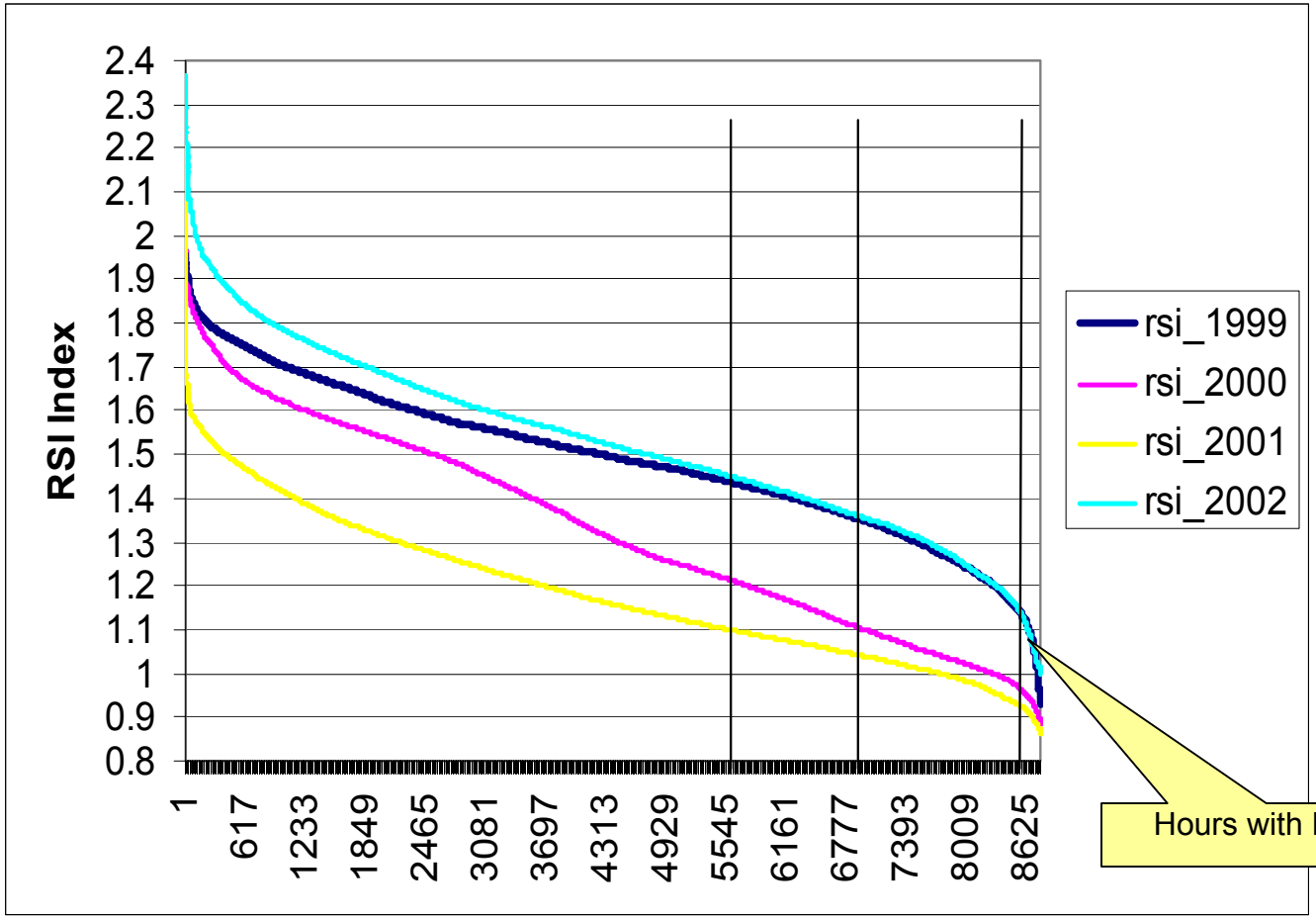
Significant correlation between the Price-cost mark-up, RSI, and actual system load



Suppliers were pivotal for 37 of the hours in 2001 and fewer than 1% of hours in 2002

Residual Supply Index Duration Curves: 1999-2002

(RSI less than 1.1 indicates suppliers able to set market prices)



Identifying Benefits by Participants Summary

For a Typical Scenario in 2013 -- Path 26 Upgrade

Perspective	Description	Consumer Benefit (mil. $)	Producer Benefit (mil. $)	Trans. Owner Benefit (mil. $)	Total Benefit (mil. $)	Production Cost Savings (mil. $)	Notes
Societal	*WECC*	50.69	(31.68)	(14.73)	4.28	4.281	
						17,096.33	Production Cost before upgrade
						17,092.05	Production Cost after upgrade
Modified Societal	*WECC*	50.69	(28.93)	(14.73)	7.04		Excludes monopoly rent
California Competitive Rent	*ISO Ratepayer Subtotal*	10.92	0.04	(1.75)	9.21		Includes consumers, UDC generators and ISO PTOs. SMUD and some munis are treated as part of the CAISO due to data limitations.
	ISO Participant Subtotal	10.92	7.04	(1.75)	16.22		Consumers, producers and transmission owners participating in CAISO markets.

Definitions:

Consumer Benefit – Reduction in cost to consumers.

Producer Benefit – Increase in producer net revenue.

Transmission Owner Benefit – Increase in congestion revenues.

WECC Societal – Sum of Consumer, Producer, and Transmission Owner Benefit in WECC.

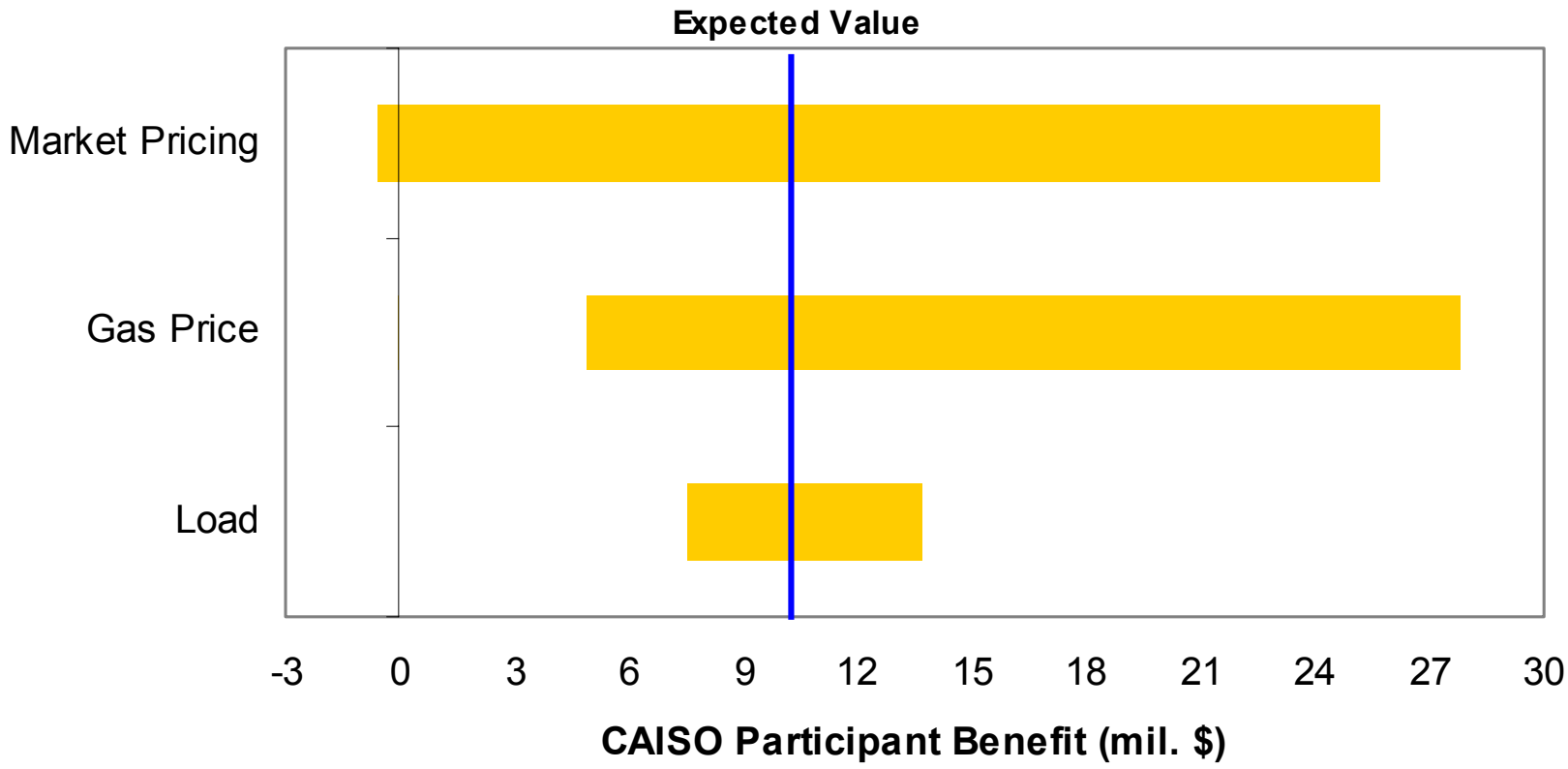
Also equal to difference in total production costs for the "without" and "with upgrade cases.

WECC Modified Societal – Same as Societal but excludes Producer Benefit derived from uncompetitive market conditions.

ISO Ratepayer –Includes ISO consumers and utility-owned generation and transmission revenue streams.

ISO Participant – Includes ISO Ratepayer plus the CA IPP Producer Benefit derived from competitive market conditions.

Potential Impact of Uncertain Variables on Benefit Calculations in 2008



Range of 2013 Annual CAISO Participant Benefits and Expected Value of Benefits for Path 26 Upgrade