Competitive Path Analysis Methodology

Prepared by Farrokh Rahimi for

CAISO MRTU Stakeholder Meeting

Folsom, CA

July 13-14, 2005
Summary of Previous CPAWG Meetings

- Meeting of June 23, 2005
  - 10 participants: 8 in person (including 1 from CAISO); 2 on the phone
  - Minutes posted (under MRTU Competitive Assessment Work Group)
  - Issues included in the list of issues discussed later in this presentation

- Phone Conference of July 6, 2005
  - 12 participants (including 3 from CAISO)
  - Minutes posted
  - Example of MISO approach for simple 2-node and 3-node systems discussed (posted)
  - Feasibility Index method discussed (posted)
  - Additional issues (included in the list of issues discussed later in this presentation)
  - Action Items:
    - CAISO:
      - Inquire about treatment of bilateral contracts in PJM and MISO studies
      - Prepare and post 10-15 node network topology for further illustration of different methods
      - Prepare pros and cons of various methods at a high level (Issues 1 and 2)
      - Propose candidate methods for treatment of imports (Issue 6)
    - SCE (Jeff Nelson): Provide proposal for consideration of effective costs in pivotal analysis (Issue 5)
    - WPTF (Ellen Wolfe):
      - Prepare candidate proposals for selection of candidate paths (Issue 3)
      - Prepare candidate proposals for treatment of contracts (Issue 7)
Problem Statement

- Transmission path constraints in the network model used under MRTU are categorized in two groups, namely Competitive and Non-competitive Paths. The distinction is central to local market power mitigation (Pre-IFM Passes 1 and 2).

- A methodology is sought to determine competitive and non-competitive paths on a periodic basis:
  - Short of a study, existing inter-zonal paths are deemed competitive and intra-zonal paths non-competitive.
  - Study to update (or confirm the list) planned to be completed by Fall 2006.
Options Under Consideration

- PJM methodology
- MISO methodology
- CAISO methodology based on Residual Supply Index (RSI)
- CAISO methodology based on Feasibility Index (FI)
PJM Approach

- PJM uses the “Delivered Price Test” for competitive path assessment, involving a combination of three tests for each candidate interface:
  - Market share threshold test
  - Market concentration test (Herfindahl-Hirschman Index, HHI)
  - Pivotal supplier test (no three jointly pivotal suppliers)
- Need not necessarily pass all 3 test to be declared competitive
  - If passed “no 3-jointly pivotal suppliers” test, declare the path competitive
  - If fails “no 3-jointly pivotal suppliers” test, would consider “no 2 or 1 pivotal supplier” in combination with below threshold market share and HHI.
  - Just passing market share and HHI tests is not enough.
- PJM conducted and filed competitive path assessment in October 2004
  - Competitive path assessment considered 11 interfaces as potential candidates to be exempted from offer capping (including traditional three)
    - Since the start of the PJM market, all PJM internal transmission interfaces except 3 were deemed uncompetitive and their congestion relief subject to “offer capping”.
    - The study resulted in one new competitive interface and confirmed the previous 3.
PJM’s Relevant Supply & Demand

- Relevant Pool of Supply
  - Start with annual load duration curve and break up into 4 load quartiles
  - For each load quartile conduct market simulation with the supply and system conditions corresponding to that load quartile
  - The main outcome of the load quartile designation and simulation is the system price (congestion-free and lossless component of the LMP)
  - For each candidate interface and each load quartile/system price construct an effective supply curve, where for each initial supply segment (Bid MW, Bid Price) with shift factor SF with respect to the candidate interface,
    - Effective MW = (Bid MW) * SF
    - Effective Price = (System Price - Bid Price)/SF
  - Partition the effective supply for each interface into 4 quartiles
  - The effective supply in each quartile defines the supply pool of interest for market share, HHI, and pivotal supplier tests (generally the first supply quartile for the top load quartile is of primary interest)

- For pivotal analysis the demand (amount of congestion relief needed) is determined from simulation or historical data
MISO Approach

- MISO uses a “no-two-pivotal supplier” test.
  - A supplier is pivotal (for congestion relief on a flowgate) when the supplier can cause or sustain binding constraint on the flowgate when its rivals’ generating resources are fully redispached to relieve the congestion
    - Start from Base Case solution
    - Potentially pivotal supplier can raise/lower and commit/decommit to cause congestion
    - Other suppliers can only raise (to Pmax) or lower (to Pmin) to relieve congestion

- MISO treated each participant as a potential pivotal supplier
  - 121 candidate flowgates were analyzed (out of some 700 total).
  - Candidate paths are those with 10 hours or more of TLR Level 3a in 2002-2003 (curtailing lowest priority non-firm schedules to allow higher priority service to be scheduled or relieve congestion).
CAISO RSI Approach

• Apply an RSI test on “effective” resources that can relieve congestion on a particular transmission path.

• If there are three or more suppliers that own effective resources and the RSI is determined to be greater than 1.2 for more than 95% of the time (during the year), the transmission path will be designated as “competitive”.

• Issues that need to be addressed:
  – Quantifying the amount of “effective supply” available for providing congestion relief. This includes the choice of the proper sinks for determination of Generation Shift Factors
  – System conditions to incorporate into forward-looking assessment (load levels, hydro availability, congestion on one path affecting unit effectiveness in relieving congestion on another path).
Determination of Generator Shift Factors

- Pivotal analysis for competitive path assessment generally requires determination and use of Generation Shift Factors
  - Generator shift factors are needed for this analysis only. They are not needed for operating and settling the LMP market.
  - A unit’s “effectiveness” in relieving congestion on a particular path will depend on the designation of the energy sink.
  - The sink can be selected at any node or collection of nodes in the network.
  - The designation of the sink can impact the results of the analysis
  - Options:
    - PJM-like Approach: Use all load nodes as the sink (distributed load sink)
    - MISO-like Approach: Use all other generators as the sink
    - Designate the sink on a case by case basis depending on the transmission path being analyzed.
Feasibility Index Method

- Does not require or use Shift Factors
- Model all transmission constraints (except possibly those that are definitely known to be competitive) as soft constraints with high violation penalty
- Remove all resources of a supplier (i) and compute the following Feasibility Index for each path (j)
  \[ \text{FI}(i,j) = \frac{\text{Path j Limit} - \text{Path j Flow}}{\text{Path j Limit}} \]
- If \( \text{FI}(i,j) < 0 \), supplier i is deemed to be pivotal for congestion relief on path j
- If \( \text{FI}(i,k) \geq 0 \) for all suppliers i, then:
  - Path k is competitive with respect to “a single pivotal supplier” test
  - Choose sets of two suppliers with the lowest FIs for path k to carry out “two-jointly pivotal supplier” test
Feasibility Index Example

1,400 MW @$25/MWh (Supplier X)

3,600 MW @$20/MWh (others)

Load = 5,000 MW

Flow Limit = 3,000 MW

Flow Limit = 1,000 MW each

Large MW Supply @$30/MWh (others)
Feasibility Index Example (Cont’d)

- Feasibility Index Screen:
  - All Supply In:
    - Feasible Solution
      - Ga = 3,000 MW; Gx = 1,400 MW; Gb = 600 MW
  - Supplier x (Gx) Removed:
    - Infeasible Solution: Apply soft constraint penalties (say $3,000/MWh) to all paths
      - Ga = 3,000 MW; Gx = 0 MW; Gb = 2,000 MW
    - FI_{B-A2} = (1,000 – 1,333)/1,000 = -0.333; FI (other paths) = 0
  - If all other suppliers each have a relatively small supply portfolio (say less than 300 MW each) then based on “no-two-pivotal-supplier” test with pivotal quantity alone (no price movement consideration) all paths except B-A2 are competitive.
Issues to be Resolved

- Methodology for assessing competitiveness
  - CAISO RSI Approach
  - CAISO Feasibility Index Approach
  - MISO Pivotal Analysis Approach
  - PJM Three-Part Test Approach (Market share, HHI, and RSI)
- Methodology for determining generator shift factors (where needed).
- Methodology for determining candidate paths to assess.
- Methodology for determining demand for congestion relief (RSI or PJM)
- Is pivotal analysis a quantity measure or should also consider effective cost?
- Treatment of imports (any analysis of potential pivotal importers?)
- Treatment of forward contracts
- Set of market conditions examined
  - Seasonal (e.g., monthly peak & off-peak)
  - Load scenarios
  - Hydro scenarios
- Should the entities considered in pivotal analysis be the SCs or Generation Owners (if different)
Issue 1: Methodology Options

- Comparative Analysis of PJM, MISO, CAISO RSI, and CAISO FI approaches:
  - Two-node and three-node examples:
    - Posted for MISO approach
    - Too small for the other methods to be meaningful
  - 16-node example underway
    - Topology posted
    - Software being upgraded for analysis
    - Preliminary results expected for mid-August

- Potential problems and concerns with different methods:
  - Choice of reference (sink) nodes for shift factor computations in MISO, PJM, and CAISO RSI methods can impact the results
  - Need to identify the amount of congestion relief (demand) in PJM and CAISO RSI approaches
  - Computational burden in CAISO FI approach can increase the amount of analysis needed to reduce the impact of candidate path processing order
Simplified Network for CPA Simulation Study

Legend:
- Competitive Paths
- Non-competitive Paths
- Loops

Note: Muni net loads not included
Issue 2: Shift Factor Methodology

- Basic property of conventional Shift Factors
  - Ignoring losses, the incremental flow on path k as a result of 1 MW injection at A and withdrawal at B is SF (A,k) – SF (B,k)

- PJM’s distributed load slack:
  - Satisfies basic property of conventional Shift Factors
  - Consistent with computation of LMP components
  - Not necessarily consistent with economic solution to congestion relief

- MISO’s distributed generation slack:
  - Does not quite satisfy the basic property of conventional Shift Factors
  - Not consistent with computation of LMP components
  - Not necessarily consistent with economic solution to congestion relief

- CAISO’s injection and path specific slack:
  - Does not satisfy the basic property of conventional Shift Factors
  - Not consistent with computation of LMP components
  - Consistent with economic solution to congestion relief
Comparison of Methods (Issues 1 & 2)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>PJM</th>
<th>MISO</th>
<th>CAISO RSI</th>
<th>CAISO FI</th>
</tr>
</thead>
</table>
| Simplicity          | Pros: None  
                      Cons: Complicated  
                      Requires congestion relief amount  
                      Requires designation of reference for system price |
| Transparency        | Pros: Clear Process  
                      Cons: Use of shift factors impacts analysis results  
                      Determination of congestion relief amount is rather arbitrary  
                      Use of supply quartiles is rather arbitrary |
| Internal Consistency| Pros: Internal consistency of shift factors  
                      Cons: Use of shift factors with load slack is not compatible with pivotal supplier analysis for congestion relief |
| Experience in Other ISOs | Yes | Yes | No | No |
Issue 3: Candidate Path Selection Criteria

- Based on historical data:
  - Congestion frequency and magnitude?
  - Cost of relieving congestion?
  - Frequency of mitigation attributable to congestion on the path in question
  - Other criteria?

- Based on simulation of typical system conditions
  - Simulated conditions?
  - Screening criteria based on simulation results?

- Based on changes in infrastructure:
  - New generation
  - New/upgraded transmission
  - Change of generation ownership
  - Demand response
Issue 4: Demand for Congestion Relief

- Needed for PJM type and RSI-based analysis
- May be needed with all methods if pivotal analysis is to be supplemented by a measure of effective cost
- Options:
  - Simulation
    - Cost-based
    - Incorporating historical market bids in simulation
    - Other?
  - Historical data
    - Amount of re-dispatch for congestion relief on the path (need to devise method to determine)
    - Amount of initial flow above limit due to “preferred” schedules (need to specify what these are)
  - Other?
Issue 5: Consideration of Effective Cost

- Implicit in the PJM method
- Ignored in the MISO method
- Not directly accounted for in CAISO’s RSI method, but could be added in defining the pool of supply
- Not directly accounted for in CAISO’s basic FI method, but could be added
  - Either as additional analysis to the basic FI method, or
  - By incorporating different penalty bands for congestion constraint violations directly in the FI method

- Framework
  - Cost-based effective cost (PJM’s 2004 competitive path analysis), or
  - Bid-based “effective bid cost”
    - RSI regression (as in CAISO’s TEAM methodology), or
    - Game theoretic simulations (Cournot, etc.?)
**Issue 6: Treatment of Imports**

- Options for Imports from Other Control Areas:
  - Assume import quantities at historical levels
  - Use historical market-clearing bids to construct import supply quantity price curves for each import path (with no designation of supplier/SC)
  - Use historical bids (regardless of whether or not they cleared) to construct supply quantity price curves (with no designation of supplier/SC)
  - Treat as potentially pivotal supply (designating individual supplier/SC)
  - Other?

- Treatment of Dynamic Schedules
  - Treat like internal resources if tied to specific resource
  - Treat like imports from other control areas if tied to Control Area ACE
  - Other suggestions?

- Others (e.g., net-seller MSS?)
Issue 7: Treatment of Contracts

- Forward contracts (with fixed prices) may reduce supplier incentives to raise prices
  - Rather simple to quantify system-wide impact on supplier strategy if contract is for fixed price and quantity for predictable system conditions (e.g., 7x24 or 6x16 fixed price contracts)
  - Difficult to determine impact in the face of congestion
    - Unclear how/where to net out
    - Unclear price impact
- PJM and MISO both ignored impact of forward contracts in their competitive path assessment
- Forward contracts with no fixed energy price (e.g., capacity type contracts) do not seem relevant to pivotal analysis for congestion relief. Comments?
Issue 8: Set of Market Conditions

• How many cases to consider for CAISO’s competitive path assessment and on what basis?
  – PJM uses historical Load Duration Curve to identify target base cases associated with load quartiles
  – MISO uses typical planning base cases for 4 different months
  – Criterion is applied to all cases; the least competitive case determines which paths are competitive

• Case attributes:
  – Network Conditions:
    • Seasonal base cases with normal operating limits,
    • Seasonal base cases with adjusted ratings to account for contingencies, or
    • Seasonal base cases with contingency list?
  – Load (and Load Distribution Factors)
  – Hydro conditions
  – Imports, depending on how they are to be treated
  – Contracts (if considered in pivotal analysis)
Issue 9: Candidate Pivotal Entities

- How to treat SCs that schedule supply from different generation owners
- How to treat generation owners whose supply portfolio is partitioned among different SCs?
- Should pivotal analysis be done on “affiliate group” basis?
  - Affiliate Groups are known for FTR ownership and control in CAISO’s FTR Market Monitoring System
  - Need to work out appropriate extension of Affiliate Groups beyond FTR ownership and control?
- Other Ideas?
Comments and Next Steps

• Comments?

• Next Steps
  – CAISO will provide a proposed approach based on the comments and input received from the Working Group.
  – CAISO will request written comments on the proposed approach by the end of July.
  – CAISO will refine proposal based on input received and present a revised approach prior to next stakeholder meeting (August 17-18).