Mixed-Integer Programming Solution at the CAISO
Presented to: Harvard Energy Policy Group
December 6, 2007

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California ISO
Your Link to Power

MIP at the CAISO

- As part of its Market Redesign and Technology Upgrade (MRTU), the is implementing Mixed Integer Programming (MIP) Solution
- In 2003 CAISO executed a Proof-of-Concept to ensure solution meets performance and solution requirements
- Planned implementation date of April 1, 2008

MIP at the CAISO

- Large number of transmission constraints
  - Up to 2000 binding constraint for 24 intervals, 150 contingencies
- Nomograms
  - Simultaneous interface vs. interface limits or interface vs.generation output limits
- Ancillary Service and Energy Co-optimization
  - Decision to procure A/S based on resources constraints
- Dynamic ramp rates ‘
  - Different ramp-rates at different operating levels
- Resource on/off decisions
  - minimum up time, minimum down time, maximum starts/day
- Forbidden Region of Operation
  - Operating regions can be crossed but not maintained inside
- Energy Limitation Constraints
  - Maximum amount of energy or hours of availability
- Pump/Storage Modeling
  - Decision regarding pumping or generation operational mode
- Constrained Output Generator (COG) (Pmin=Pmax) Dispatch and Pricing

Current vs. Planned Approaches

	Current Approach	Planned Approach	Date of Planned Implementation of MIP	Estimated Annual Savings
Real-time market look ahead	LR used for 2 hour look ahead commitment and dispatch	MIP: 2 hour look ahead for dispatch. As long as 5 hours for commitment .	April 1, 2008	~$100,000-$1 million (0.1%-1%1 of 2006 RT Dispatch Costs and RT RMR Costs2: $97 million)
Residual unit commitment	Procedural based operator judgement advised by a MIP based UC with no network	Run a MIP, Full Network Model based on Residual Unit Commitment after Day-Ahead bid market.	April 1, 2008	~$100,000-$1 million (based on 0.1% - 1% of Total Minimum Load Costs for 2006: $106 million)
day-ahead market	Linear Programing: No unit commitment, No Energy Optimziation, Allocation of Transmission only using zonal model	Run a MIP based SCUC/SCED, Full Network Model program, Energy and A/S co-optimized	April 1, 2008	~$2.3-$23 million (Assumes an estimated 0.1%-1% reduction of $11.4 billion Energy and Ancillary Service)
Capacity market	None	Policy being considered	Policy being considered	No Estimate
Ancillary service market	Linear Programming sequential procured after Transmission Allocation	Run a MIP based SCUC/SCED, Full Network Model program co-optimized with energy	April 1, 2008	~$230,000-$2.3 million (0.1%-1%[1] of 2006 A/S costs[2] of $234 million)
planning	Powerflow studies	No immediate plans to incorporate MIP	No immediate plans to incorporate MIP	No Estimate

Facts about the MIP Solution and Testing Observations

- ~35,000 integer variables
- Up to 2000 Binding Constraints for 24 intervals
- DAM 24 hour simultaneous intervals run ~ 1 hour computing time
  - 2 passes, 1 – Market Power Mitigation / Reliability Requirements
  - 1 pass – Integrated Forward Market (Energy and A/S)
  - 1 pass – Residual Unit Commitment
  - 1 pass = 3-4 SCUC-NA Iterations, 1 scheduling run, 1 pricing run
- RT Unit Commitment up to 18-15 minute intervals ~ 12 minutes computing time
  - 2 passes, 1 – Market Power Mitigation / Reliability Requirements
  - 1 pass, Real-Time Unit Commitment and A/S procurement
  - 1 pass = 3-4 SCUC-NA Iterations, 1 scheduling run, 1 pricing run
- RT Dispatch up to 13-5 minute intervals ~ 2.5 minutes
  - 1 pass, Real-Time Dispatch
  - 1 pass = Security Constrained Dispatch1 scheduling run, 1 pricing run,
- MIP Gap ~ 0.2%-0.5% for 24 hour DA runs, Lower MIP Gaps can be achieved if allowed to run longer
- Observed more constraints enforced sometimes results in faster solution within MIP Gap

Future Market Initiatives That May Leverage MIP Capabilities

- Modeling of Combined Cycle Resources
  - Multiple Start-up functions
  - Start-up decisions of different stages of
- Demand Response
  - Curtailment Decisions
  - Shut-down constraints
  - Linkages between different demand
- Increase number of ramp rates ‘
  - Different ramp-rates at different operating levels
- Enhance Forbidden Region with Hold-Time Constraints
  - Must stay above forbidden region for specified period of time
- Application of Priorities
  - Possible replacement of penalty functions to enforce scheduling priorities (i.e. ETC, RMR, TOR, Self-Schedules….)
- Multi-Day Optimization
  - Improve cross-day unit commitment decision making and avoid unnecessary cycling

Questions/Feedback