SPP Integrated Marketplace-Unit Commitment

FERC Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software

June 22-24, 2015

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Southwest Power Pool

• Independent, non-profit, Regional Transmission Organization
• ~550 employees
• Membership in 8 states
  • Arkansas, Kansas, Louisiana, Missouri, Nebraska, New Mexico, Oklahoma, and Texas
• Located in Little Rock, Arkansas
  • 24 x 7 operations
  • Reliability Coordination
  • Market Operations
  • Transmission Planning
  • Tariff Administration
  • Regional Scheduling
What is Integrated Marketplace?

• New “Day-2” Market Implemented March 1, 2014
  ➢ Replaced Energy Imbalance Service (EIS) Market launched in 2007
• SPP consolidated all EIS member Balancing Authorities (BA) into one SPP BA
• Day-Ahead Market, Reliability Unit Commitment, Real-Time Balancing, and Transmission Congestion Rights (TCR)
  ➢ Products: Energy, Regulation-Up, Regulation-Down, Spinning, Supplemental
  ➢ Security Constrained Unit Commitment (SCUC), Security Constrained Economic Dispatch (SCED), Co-Optimization
Marketplace After 12 Months

• 122 Market Participants
  – Financial only and asset owning

• SPP BA has maintained control performance standards
  – Minimized inadvertent as much as possible

• System availability has exceeded expectations
  – Day-Ahead Market has posted on-time every day except once in early June (due to a modeling issue)
  – Real-Time Balancing Market has successfully solved 99.98% of all intervals
    ▪ Considerably higher than during Market Trials
Capacity Overage

- EIS (Year prior to Go-Live)
- IM (Year after Go-Live)

*Overage=Economic Max - Load - NSI - (RegUp+SPIN+SUPP)
Reliability Unit Commitments

Unit Commitment Percentages (Number of Commitments)
- 72% of commitments have come out of the DA Market
- 17% of commitments were self-commits after the DA Market
- 11% of commitments have come out of the RUC process

Unit Commitment Percentages (MWh’s of Commitments)
- 95.3% of commitments have come out of the DA Market
- 2.2% of commitments were self-commits after the DA Market
- 2.5% of commitments have come out of the RUC process
Average Hourly Load Participation in DA Market

- Cleared Demand as a Percent of Reported Load - OffPeak
- Cleared Demand as a Percent of Reported Load - On Peak
Virtual Participation in Marketplace

- Mar-14: 4.0% Cleared Virtual Bids, 2.0% Cleared Virtual Offers
- Apr-14: 9.0% Cleared Virtual Bids, 1.0% Cleared Virtual Offers
- May-14: 7.0% Cleared Virtual Bids, 3.0% Cleared Virtual Offers
- Jun-14: 6.0% Cleared Virtual Bids, 4.0% Cleared Virtual Offers
- Jul-14: 5.0% Cleared Virtual Bids, 5.0% Cleared Virtual Offers
- Aug-14: 6.0% Cleared Virtual Bids, 4.0% Cleared Virtual Offers
- Sep-14: 7.0% Cleared Virtual Bids, 3.0% Cleared Virtual Offers
- Oct-14: 9.0% Cleared Virtual Bids, 1.0% Cleared Virtual Offers
- Nov-14: 7.0% Cleared Virtual Bids, 3.0% Cleared Virtual Offers
- Dec-14: 6.0% Cleared Virtual Bids, 4.0% Cleared Virtual Offers
- Jan-15: 8.0% Cleared Virtual Bids, 2.0% Cleared Virtual Offers
- Feb-15: 6.0% Cleared Virtual Bids, 4.0% Cleared Virtual Offers
Challenges

- Involved extensively in IM market process:
  - SCUC in DAMKT, DA-RUC, DBDA-RUC, ID-RUC, PA-RUC
    - One engine for all
    - Study window, input data, and objectives all vary by type
    - Flexible, robust and efficient
Challenges

• Large complicated SCUC model:
  – Individual Regulation up and regulation down AS product
  – Recallable Transactions: supplemental reserve
  – Variable Energy Resources (VERs): regulation down only
  – External Dynamic Resources (EDRs):
    ▪ AC-Ties: provide AS by deviating the scheduled energy output
    ▪ DC-ties: bi-directional energy transfer
  – Demand Response Resources: dispatchable or block, unlocked for emergency
  – Linearize ALL the offers (resources, bids, virtual): more continuous variables
  – Large number of resources have maximum daily energy constraints or maximum run time constraints
Challenges

• Include Mitigation process:
  – Normal SCUC solve: non-mitigated solve
  – Mitigated SCUC solve: Market Impact test solve

• Complex Logic for scarcity and emergency conditions:
  – Scarcity and emergency condition detection with corrective actions
  – Different procedures in DA and RUC
  – AS Scarcity, Capacity Shortage and Excess Gen
  – Non-firm transactions curtailment
  – Emergency Range Release/Reliability resource commitment
  – De-commitment of Must Run resources under minimum generation emergency
Performance

• Configurations:
  – Linux application server
  – Xeon E5-2690 (v1) processor
  – CPLEX 12.5
  – Expect to reach 0.1% MIP Relative Gap within 1200 seconds
  – Configurable for single thread or multiple threads
  – Single threaded performance of a CPU still tends to dominate the factors of MIP solve time
  – Utilizing CPLEX’s parallel MIP methods have shown solve time improvement in some cases
Performance

• Observed issues in the earlier phase of the project:
  – Timed out case with unacceptable solution
  – Numerical instability due to Scaling issue: large penalty price vs. small offer price and sensitivities. Slow convergence when the actual gap is getting small
  – Penalty price setting impact the performance and case dependent
  – Terminate prematurely with large objective cost dominated by violation penalty cost
  – Incorrect identify scarcity and emergency condition
  – Easily causing inconsistency between mitigation test solve and mitigated solve
Multi-stage SCUC Algorithm

• Resource Feasibility Stage:
  – Modeling
    ▪ Ignore operating costs and system constraints
    ▪ Minimize resource constraint violations
  – Goals and benefits
    ▪ Handle input data/condition conflicts at resource level
    ▪ Remove unnecessary violations
    ▪ Improve robustness and solution quality
    ▪ Decoupled model at resource level
    ▪ Quick solve
Multi-stage SCUC algorithm

• System Feasibility stage:
  – Modeling
    ▪ Ignore operating cost
    ▪ Include system constraint and hard resource constraints with necessary relaxation
    ▪ Minimize system constraint violation
  – Goals and benefits
    ▪ Not solved for optimal SCUC solution
    ▪ Quickly detect scarcity/emergency conditions
    ▪ Avoid incorrect determination due to the penalty price setting vs large SU/noload cost
Multi-stage SCUC algorithm

• Optimal Solution stage:
  – Modeling
    ▪ Full SCUC model including operating cost
    ▪ Hard resource constraints and some system constraints with pre-determined relaxation
  – Goals and Benefits
    ▪ Focus on optimal SCUC solution
    ▪ Warm-start from system feasibility stage
    ▪ the only solve needed or mitigation impact test solve and mitigated solve
    ▪ Warm-start from non-mitigated optimality solve
    ▪ Better solution qualify even when the solve times out
# Result Comparison

<table>
<thead>
<tr>
<th>Steps</th>
<th>Result</th>
<th>Performance</th>
<th>Sub-steps</th>
<th>Result</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Resource Feasibility</strong></td>
<td>14 max-run time violations 1 max daily energy violation</td>
<td></td>
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<tr>
<td><strong>Normal solve</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td><strong>Obj.</strong> 33174382</td>
<td><strong>Vio.</strong> 206845</td>
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<td></td>
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<td></td>
<td><strong>RscOprcost</strong> 32967536</td>
<td><strong>Solution time</strong> 198.652(s)</td>
<td><strong>Act. Gap</strong> 0.09% <strong>Abs. Gap</strong> 30914</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>System Feasibility</strong></td>
<td>no system constraint violation</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Obj.</strong> 0</td>
<td><strong>Vio.</strong> 0</td>
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<td></td>
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<td></td>
<td><strong>Solution time</strong> 71(s)</td>
<td><strong>Act. Gap</strong> 0% <strong>Abs. Gap</strong> 0</td>
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<td><strong>Optimality</strong> solved with the desired gap</td>
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<td></td>
<td><strong>Obj.</strong> 33412988</td>
<td><strong>Vio.</strong> 0</td>
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<td></td>
<td><strong>Solution time</strong> 220.984(s)</td>
<td><strong>Act. Gap</strong> 0.02% <strong>Abs. Gap</strong> 7886</td>
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<td><strong>Reliability commitment</strong></td>
<td><strong>Objective</strong> 33412988</td>
<td><strong>Vio.</strong> 0</td>
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<td></td>
<td><strong>Solution time</strong> 101.984(s)</td>
<td><strong>Act. Gap</strong> 0.04% <strong>Abs. Gap</strong> 13688</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Mitigate d SCUC</strong></td>
<td>disabled due to emergency condition</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Optimality</strong> solved with the desired gap</td>
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Future Challenges

• Desire for ever increasing performance to shorten the time taken to solve.

• Enhanced Combined Cycle

• Grouped Resource constraint modeling (shared startup transformer or shared plant operators)

• Decrease mismatch in SCUC and SCED models
Helping our members work together to keep the lights on... today and in the future