

SPP Integrated Marketplace- Unit Commitment

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

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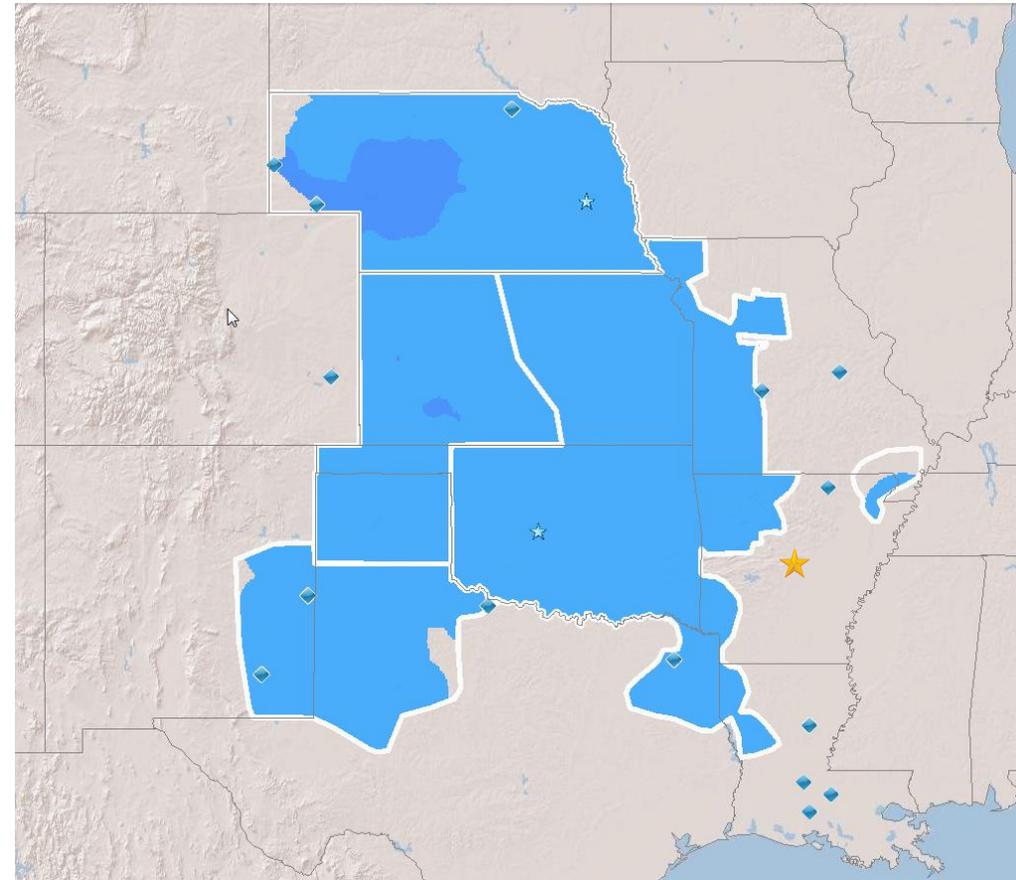
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Southwest Power Pool

- 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

Reliability Unit Commitments

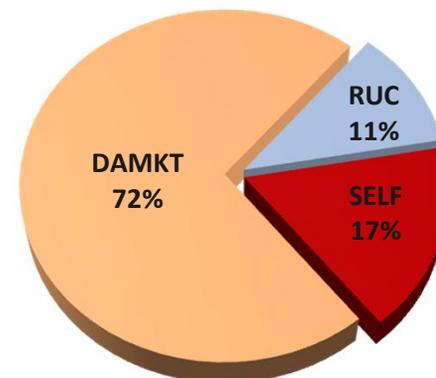
Unit Commitment Percentages (Number of Commitments)

- 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

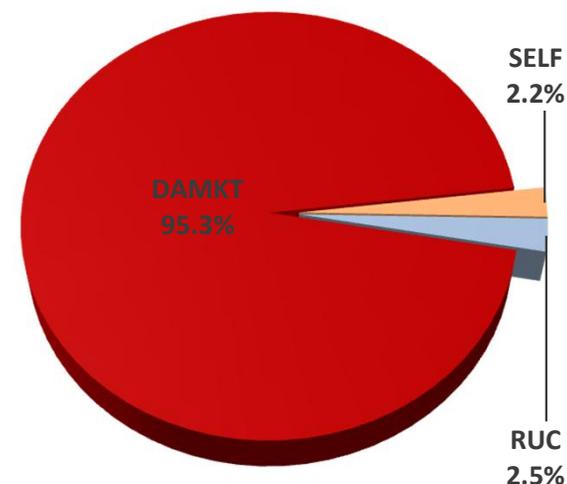
Unit Commitment Percentages (MWh's of Commitments)

- 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

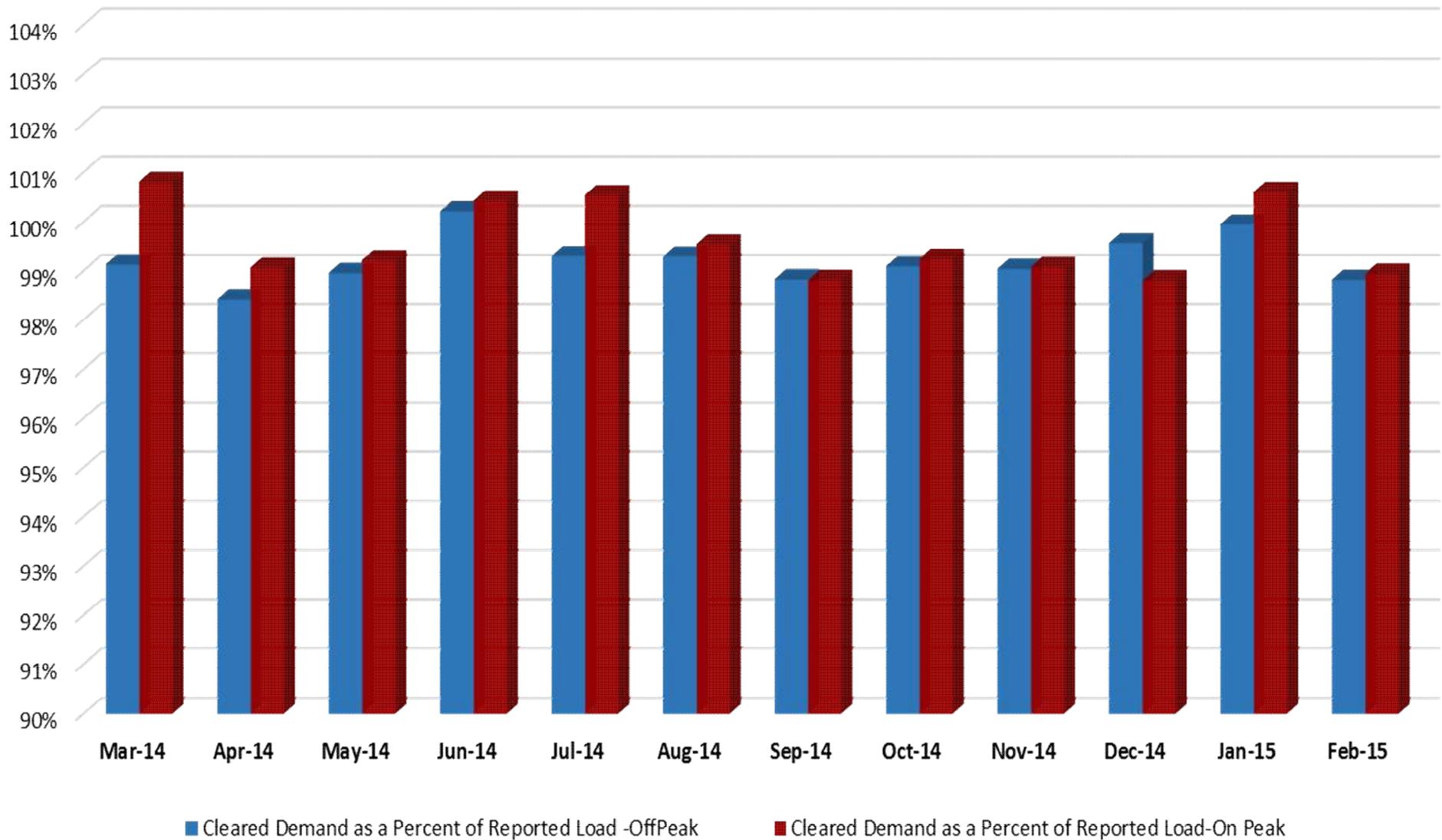
Centralized Unit Commitment (Number of Commitments)



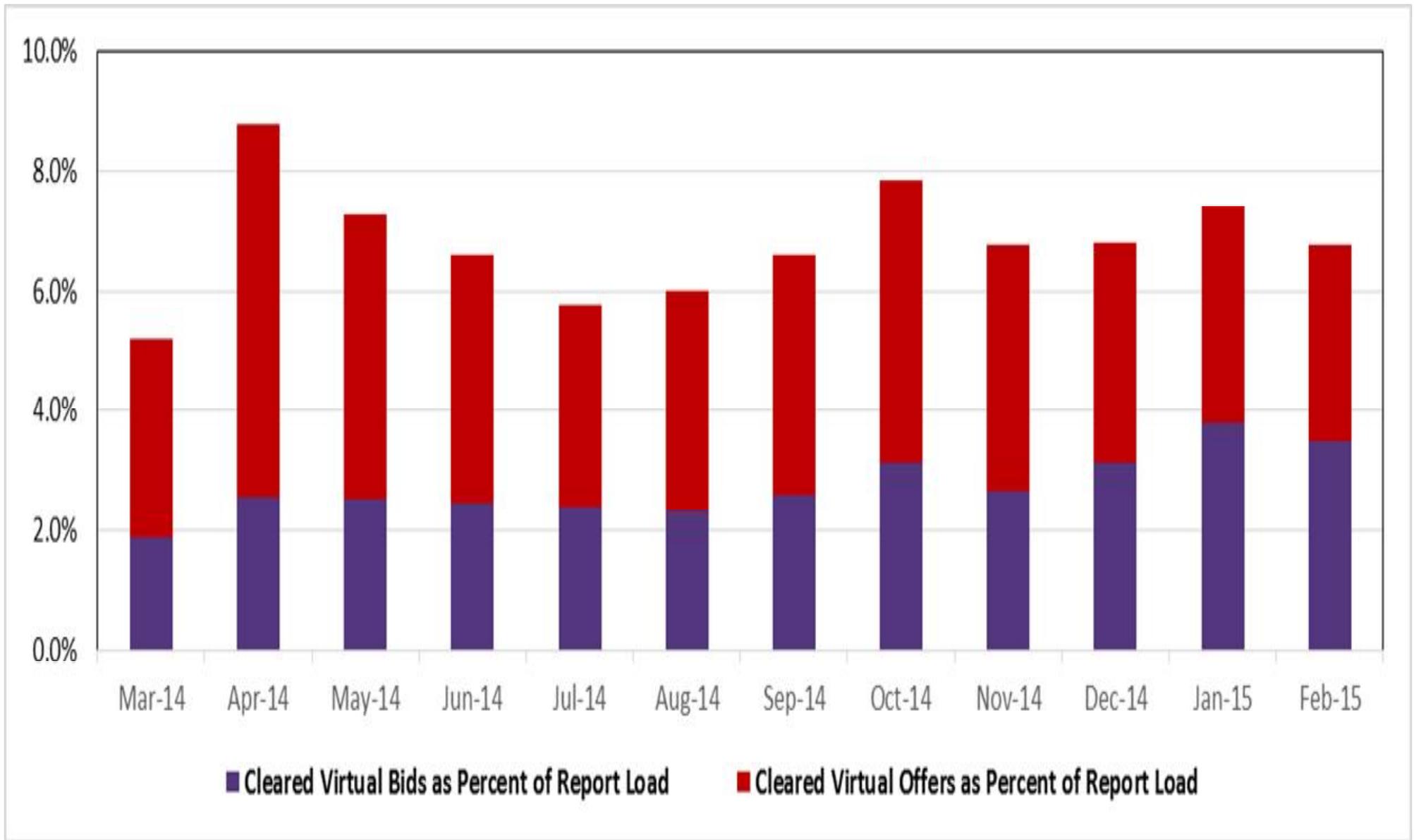
Centralized Unit Commitment (MWh's of Commitments)



Average Hourly Load Participation in DA Market



Virtual Participation in Marketplace



Challenges

- Involved extensively in IM market process :

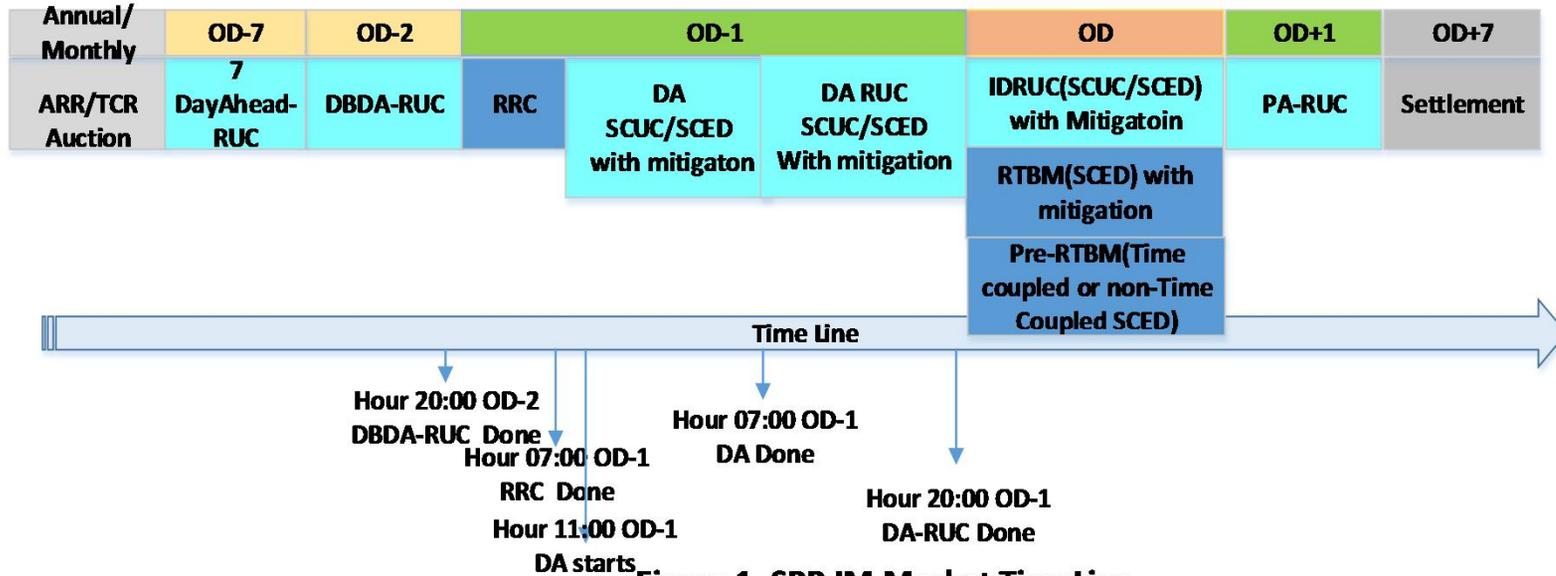


Figure 1. SPP IM Market Timeline

- 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

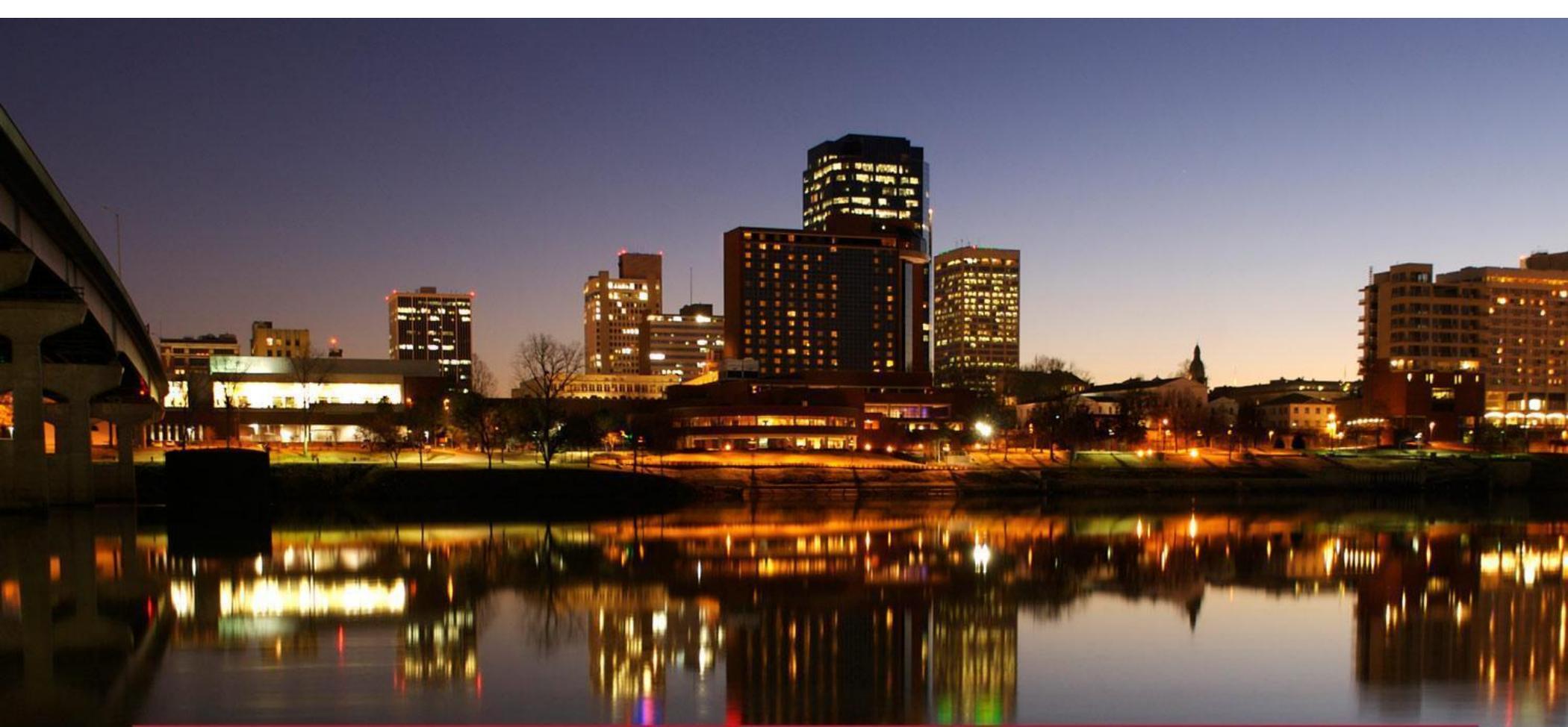
- **Optimal Solution stage:**
 - **Modeling**
 - Full SCUC model including operating cost
 - Hard resource constraints and some system constraints with pre-determined relaxation
 - **Goals and Benefits**
 - Focus on optimal SCUC solution
 - Warm-start from system feasibility stage
 - the only solve needed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

Result Comparison

One-stage SCUC			Multi-stage SCUC		
Steps	Result	Performance	Sub-steps	Result	Performance
Normal solve	identify gen deficit	Obj. : 33174382 Vio : 206845 RscOprcost : 32967536 Solution time : 198.652(s) Act. Gap : 0.09% Abs. Gap : 30914	Resource Feasibility	14 max-run time violations 1 max daily energy violation	Obj. : 166 Vio. : 0 Solution time : 31(s) Act.l Gap : 0% Abs. Gap : 0
			System Feasibility	no system constraint violation	Obj. : 0 Vio. : 0 Solution time : 71(s) Act. Gap : 0% Abs. Gap : 0
			Optimality	solved with the desired gap	Obj. : 33412988 Vio. : 0 Solution time : 220.984(s) Act. Gap : 0.02% Abs. Gap : 7886
Reliability commitment	triggered	Obj. : 39322062 Vio. : 102327 RscOprcost : 39219735 Solution time : 167.405(s) Act. Gap : 0.02% Abs. Gap : 6533			NA
Mitigated SCUC	NA	disabled due to emergency condition	Optimality	solved with the desired gap	Objective : 33412988 Vio. : 0 Solution time : 101.984(s) Act.Gap : 0.04% Abs. Gap : 13688

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

 **SPP** *Southwest
Power Pool*

GRID

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