

Operational and Practical Considerations for Stochastic Unit Commitment Solutions

FERC Technical Conference
Increasing RT & DA Market Efficiency Through Improved Software

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June 23rd, 2014

Outline

- Legacy Issues
 - Uncertainties
- Paradigm Shift to Stochastic Programming Solvers
 - What is Changing?
- What Could Be The Next Steps?
 - Day Ahead vs RAC
 - Operational Issues and Scenario Screening
 - Managing Uncertainty in One Shot or Water Fall Approach
- Questions

Legacy Issues

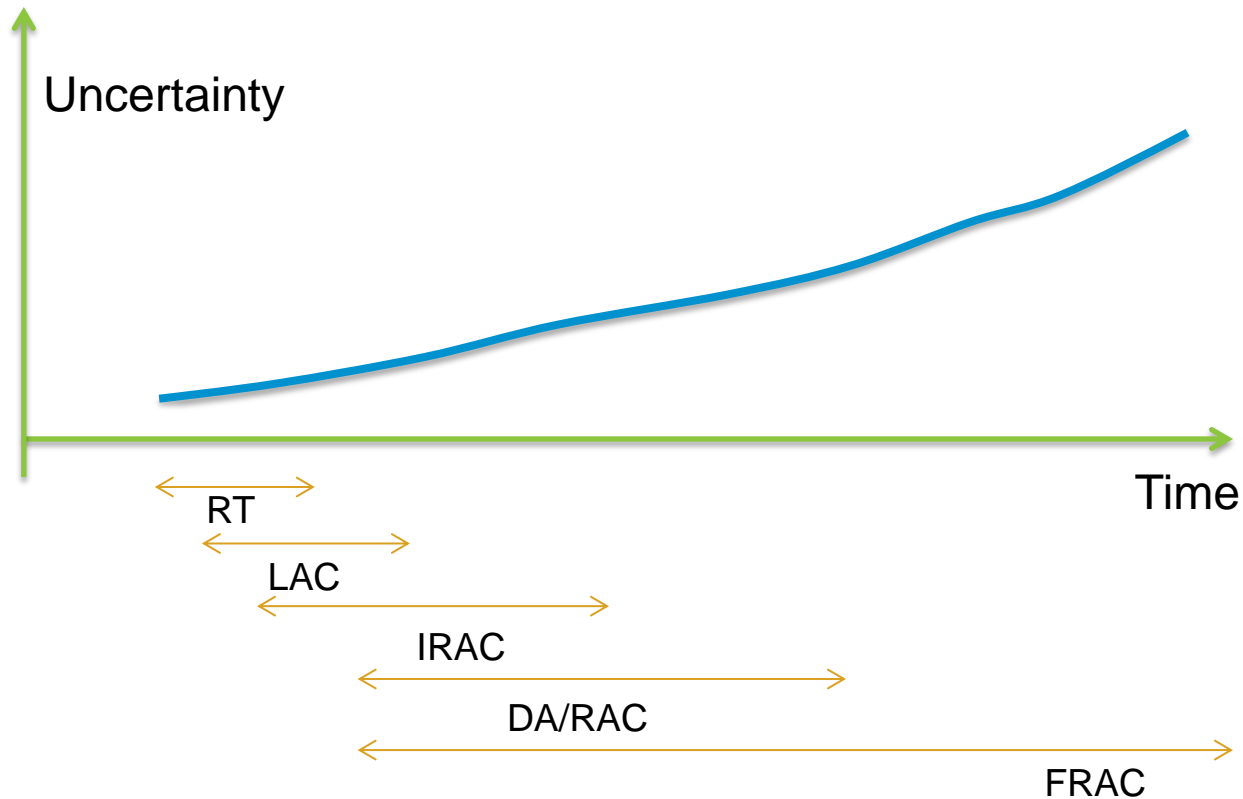
- Unit Commitment Accuracy has been challenged by the quality of the input data and modelling assumptions
 - Accuracy of the forecasted values (uncertainties)
 - Duration of study intervals (dominantly an hour) masked many intra-hour variations (not granular enough in some cases)
 - Simplified network model
 - Simplified mathematical model(s)
 - System conditions keep changing (resource availability, network topology)
 - On the other hand, limitations imposed by solution algorithms
- Keeping solution time within a reasonable range for large scale system forces additional simplifications and inaccuracies

Uncertainties Sources

- Net Load (Load net of renewable energy and net scheduled Interchanges) Variability and Uncertainty are rising in general
- Main contributors
 - Load
 - Renewable energy (variable generation) – including SMART Grid technologies
 - Increasing granularity and variability of the Net Scheduled Interchange

Uncertainty in Different Horizons

- Level of uncertainty grows as scheduling horizon grows



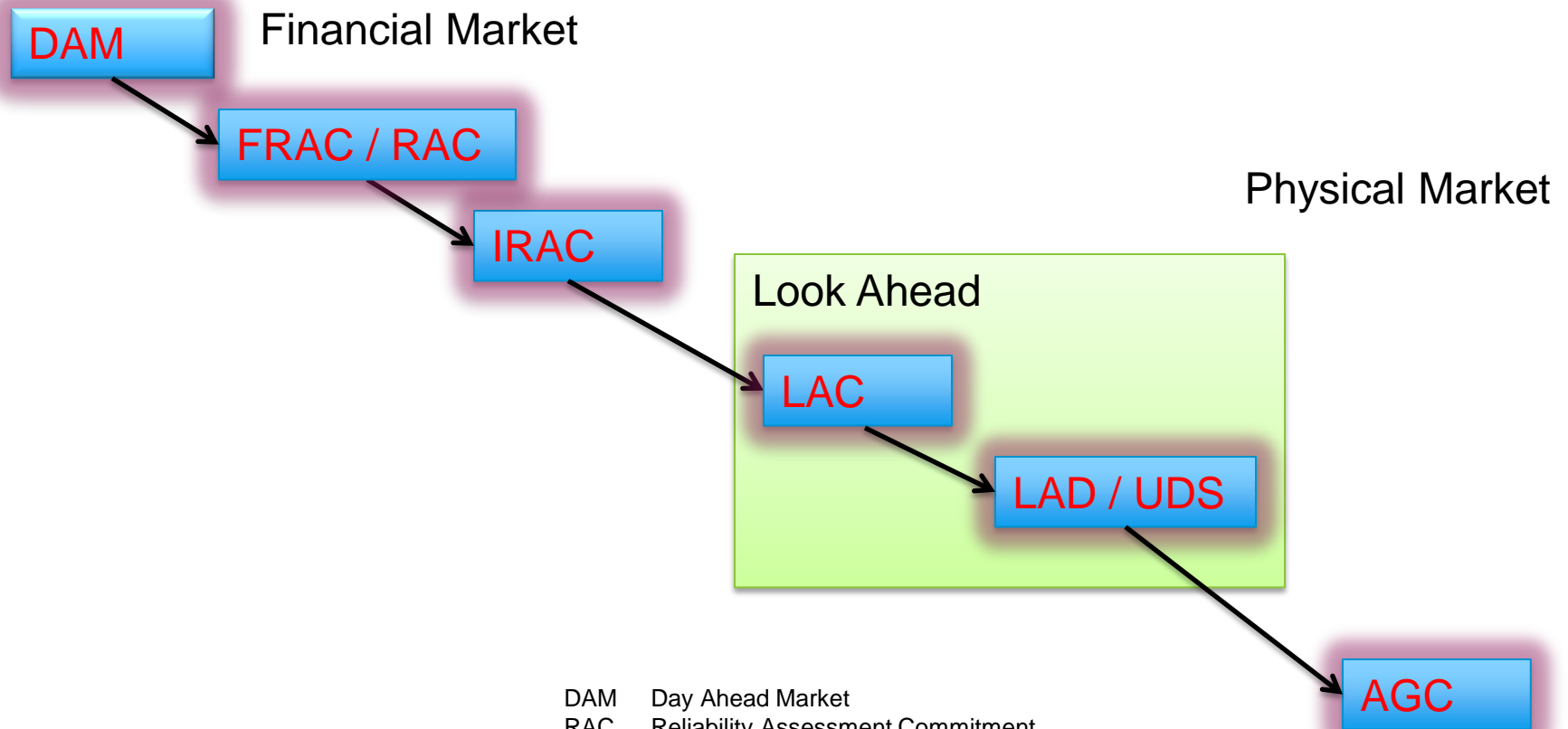
What Can We Do?

- There are a few options for system operator
 - Rely on conventional reserves (e.g., regulation and Contingency reserves) or reserve margins
 - Negative Impact: Reserve requirement will increase followed by production cost increase
 - Rely on intensive operational procedures
 - Modify the commitment process more often
 - Frequently utilize fast start up units
 - Artificially Pre-position generation levels of units
 - Negative Impact: Out of market decisions create uplifts and reduced market transparency
 - Rely on market enhancements
 - More granular market clearing process – computationally challenging
 - New solution technologies
 - Combinations of above items

Waterfall Commitment Scheme

- DA/RAC Commitment
 - Basic commitments with the specific level of uncertainty
 - Long lead units are committed in this stage
 - Incremental Commitment afterwards
 - Updates to the original commitments based on the updated input data
 - ***Trade off between higher uncertainty in upstream functions and higher chance to commit cheaper long lead start up units***

Market Coverage



DAM Day Ahead Market
RAC Reliability Assessment Commitment
FRAC Forward Reliability Assessment Commitment
IRAC Intra day Reliability Assessment Commitment
LAC Look Ahead Commitment
LAD Look Ahead Dispatch (Currently UDS)
AGC Automatic Generation Control

Paradigm Shift to Stochastic Solutions

- **Main Claim:** Reduction in Reserve Margins which in turn will reduce the production cost
- Two major classes of solvers:
 - Stochastic optimization methods
 - Based on simulation scenarios, thus the quality and quantity of scenarios effect the optimality and even feasibility of the solution
 - Occasionally reduced scenario strategy cannot guarantee system security
 - Robust optimization
 - Based on the worst case scenario and transition among them in different intervals
 - Hybrid Solver methodology

Paradigm Shift to Stochastic Solutions- Cont'd

- Stochastic programming solvers tend toward to more economical solutions and robust optimization solvers toward more secure solutions.
- The main focus of the majority of the research work up to now:
 - Reduced scenarios for Load forecast error
 - Recent works for inclusion of variable generation
 - Commitment decisions as part of RAC (RUC) process
 - Standalone commitment decisions with no correlation with market system
 - The entire uncertainty in the commitment (scheduling) horizon have been imbedded into the problem
- Challenges:
 - Computationally intensive
 - Mismatches with current market design
 - Mismatches with current operational Paradigm

What Could be the Next Steps?

- Transition of this type of technology to the operational horizon and making it a sellable idea to all market participants there are a number of gaps which need some more attention or clarification:
 - The exact fit with the Day Ahead Market
 - Operational challenges as part of scenario screening
 - Existing hierarchical solution methodologies for managing uncertainty vs. one stop shopping as introduced in proposed stochastic solver methodologies

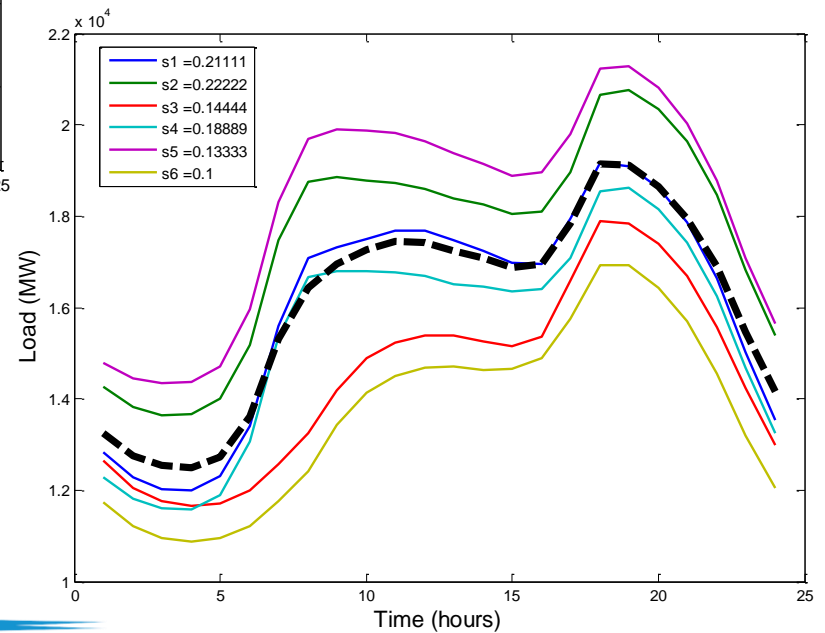
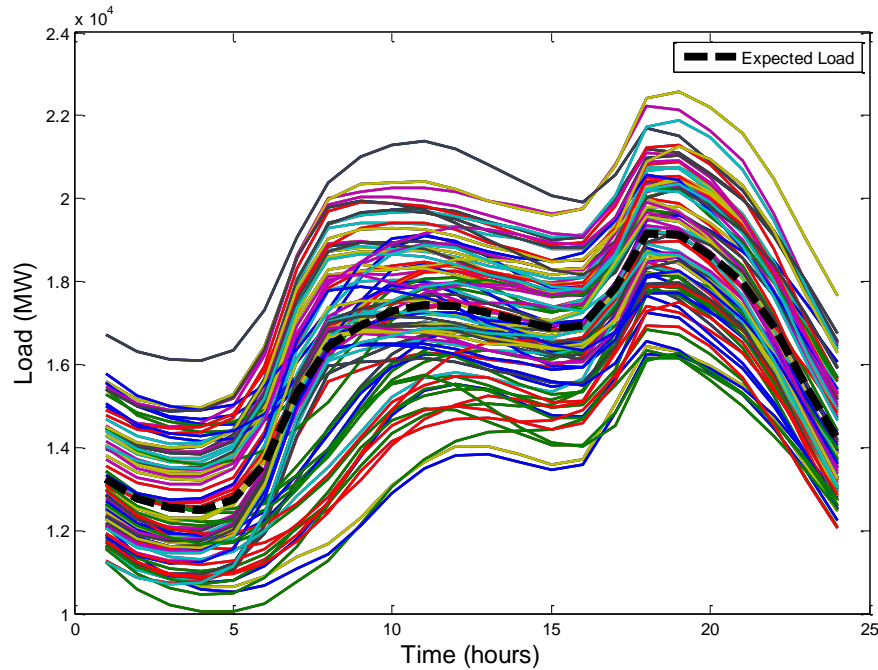
Day Ahead or RAC

- Current market systems in different set ups have one commonality:
 - Main commitment decisions in DA process and incremental commitment decisions in RAC process
- For obvious reasons many research works up to now introduced the stochastic unit commitment as part of RAC process not DA, however, the focus of these works were on full commitment not on incremental commitments
 - The effectiveness of the stochastic UC decisions needs to be evaluated under incremental commitment conditions not full commitments and all other interactions for DA commitments should be evaluated

Operational Challenges and Scenario Screening

- Different techniques have been used to reduced the number of scenarios which in turn impact the statistical probability associated with those scenarios.
- Assigned probability to scenarios are used in the objective function
 - The assigned probability to each scenario will affect commitment and dispatch decisions.
 - In different time intervals, each scenario could be evaluated differently from operational perspective
 - Time dependent weight factors

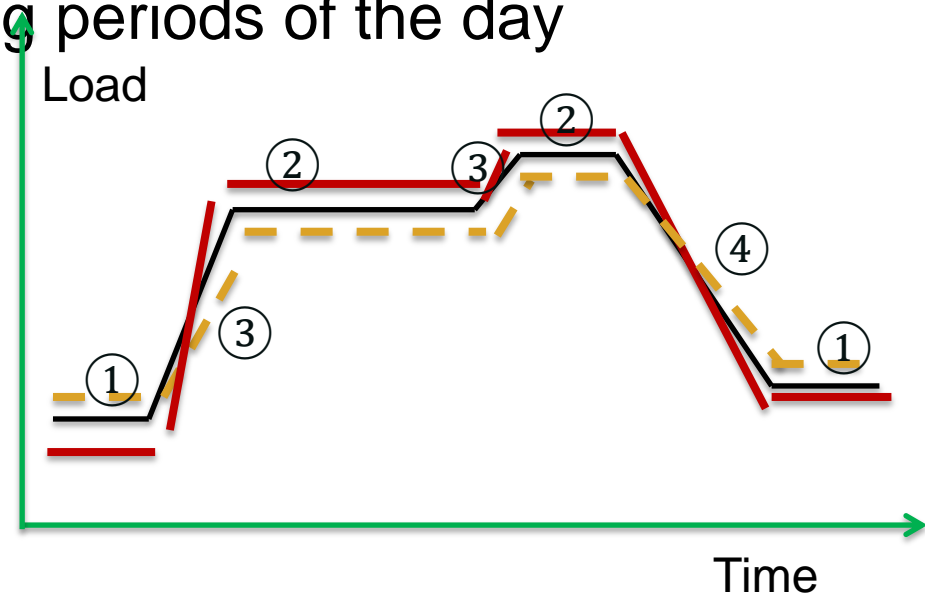
Reduced Scenario Set with Associated Probability Index



Operational Daily Challenges

- In off peak periods, those scenarios pushing toward lower envelopes could impose min. gen. events
- In peak periods, those scenarios pushing upwards could challenge capacity issues
- Steep changes in Ramp and ramp down periods could be the most challenging periods of the day

Statistically driven weight factor in the objective function are not reflective of these operational challenges



Managing Uncertainty In One Shot

- Current waterfall approach for the incremental commitment enhancement avoids the necessity to schedule a large reserve margin in RAC process to cover the entire uncertainty in the range of next 36 hours (from inception of the DA market to the end of the scheduling horizon)
- Earlier decisions allow utilizing the economical/marginal units which require longer lead times (longer start up periods)
 - Trade-off between the early decision and lower reserve margins could be a function of marginal units with not so long start up time
- **Managing the entire DA uncertainty in stochastic UC in the RAC process could negate the economical benefits of main claim for reduction in the reserve margin**
 - **If incremental RAC commitments should cover all system uncertainty, solution may not lead to lowest operating cost**

Questions