PNNL-SA-84695

Predicting Uncertainties for Real-Time and Day-Ahead Operations

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on behalf of:
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Presentation for California Energy Commission Staff Workshop
"Solar and Wind Forecasting: Achieving a 33% Solution"
December 16, 2011

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Energy Mission Business Area:
Electricity Infrastructure

- Electric power systems expertise
- Research and development of tools for enhancing electric power system reliability, security, and operational effectiveness
- Electricity Infrastructure Operations Center (EIOC), a national research test bed
- Real-time wide-area situational awareness of the electric grid through an integrated measurement system
- Analysis of large-scale renewable integration to the existing grid
- Advanced information, networking, and cyber security for reliability management services

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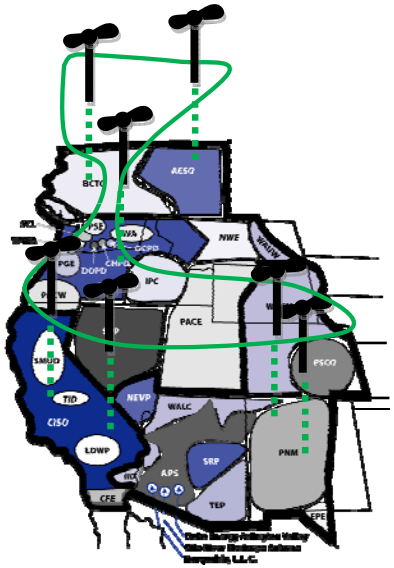
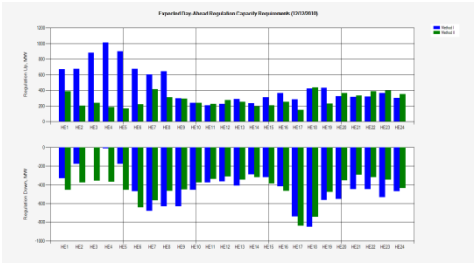
Enabling Renewables Integration at PNNL
Develop and Implement Operational Methods

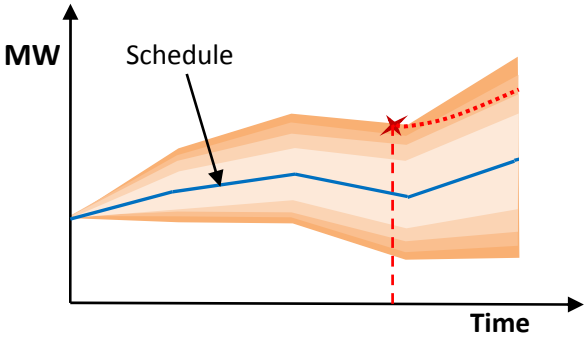
- ***Coordination & consolidation of Balancing Areas***



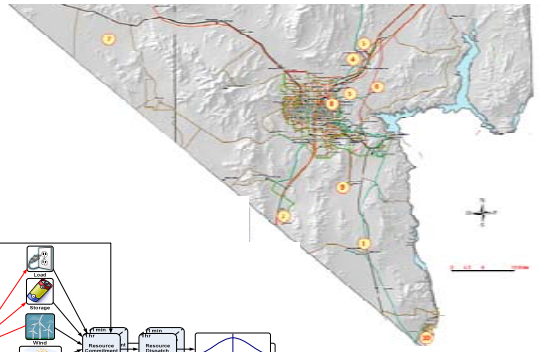
- ***New low-impact control algorithms***



- ***Methods to accommodate renewable uncertainty***

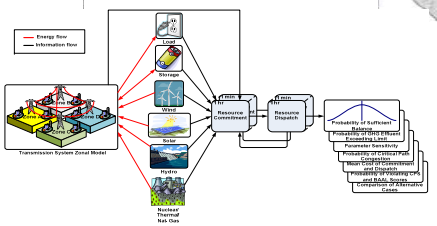


- ***Regional & Utility Studies***



- ***New models to develop/operate a different grid***

GridLAB-D ***High-resolution distribution simulator***



Renewable Integration Model

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Acknowledgements

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  - Energy Efficiency and Renewable Energy Office, U.S. Department of Energy
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  - California Independent System Operator (CAISO)
  - California Institute for Energy and Environment (CIEE)
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  - ColumbiaGrid Corporation
  - AREVA
  - Nevada Energy, and
  - Laboratory Directed Research and Development grants at PNNL

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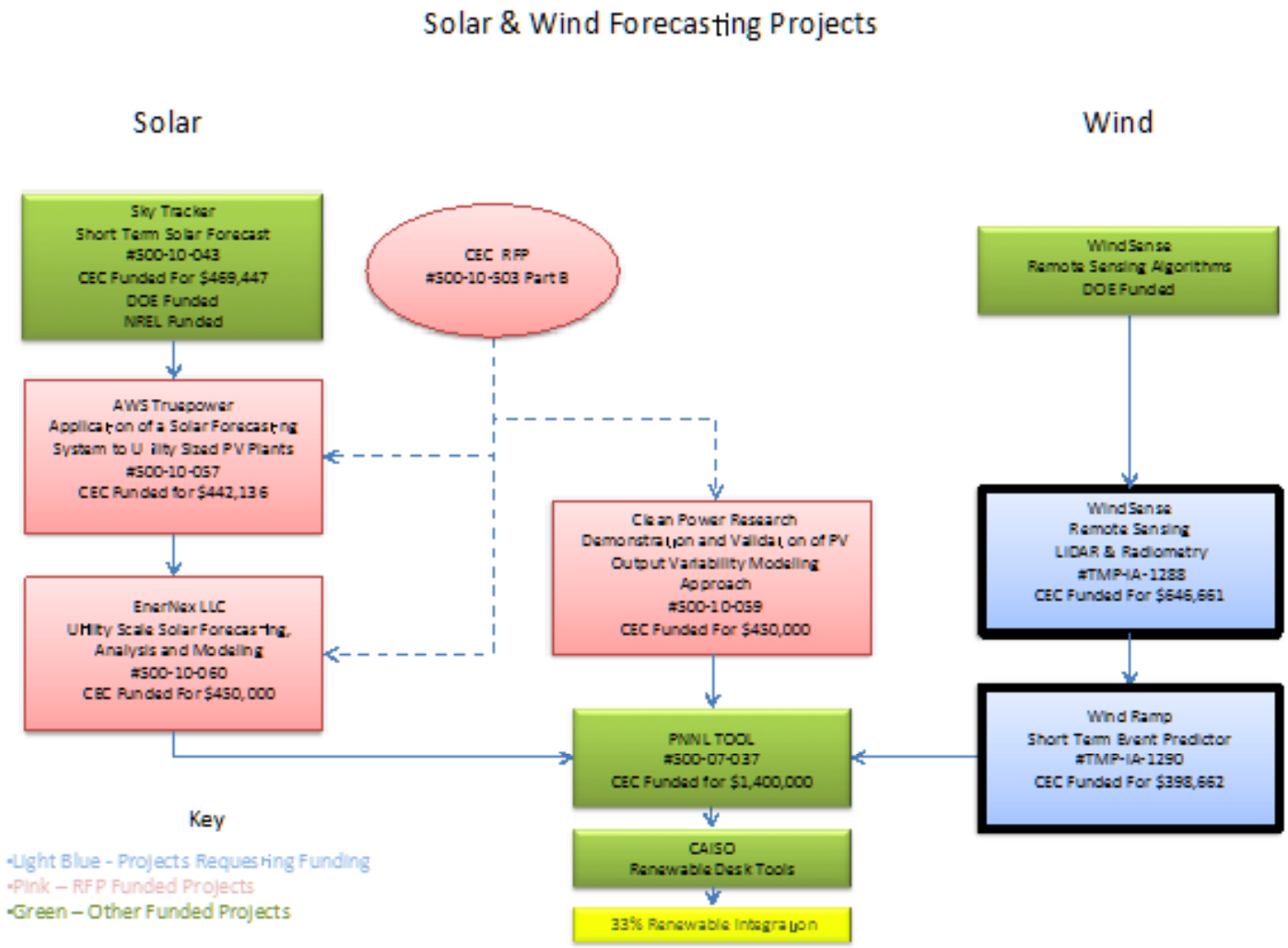
How this work relates to other activities



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Ramp and Uncertainty Prediction Tool

Integration of forecasting and renewable energy production tools into grid resource planning and operation tools

- Forecasting generation capacity and ramp ranges needed to balance the system (orange bands)
- Incorporating all sources of uncertainty/variability: wind and solar generation and demand
- Example Outcome: predicting generation deficiency above the available range (gray band)
- Tool is installed at the CAISO Control Center to help real-time dispatchers anticipate and address ramping needs.; Planned deployment to other ISOs

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*** Patricia Hoffman (Assistant Secretary, DOE), "Maximizing Renewable Energy in the US Electric Grid," Presentation at The Road to a 100% Renewable Energy System Workshop, August 1, 2011**

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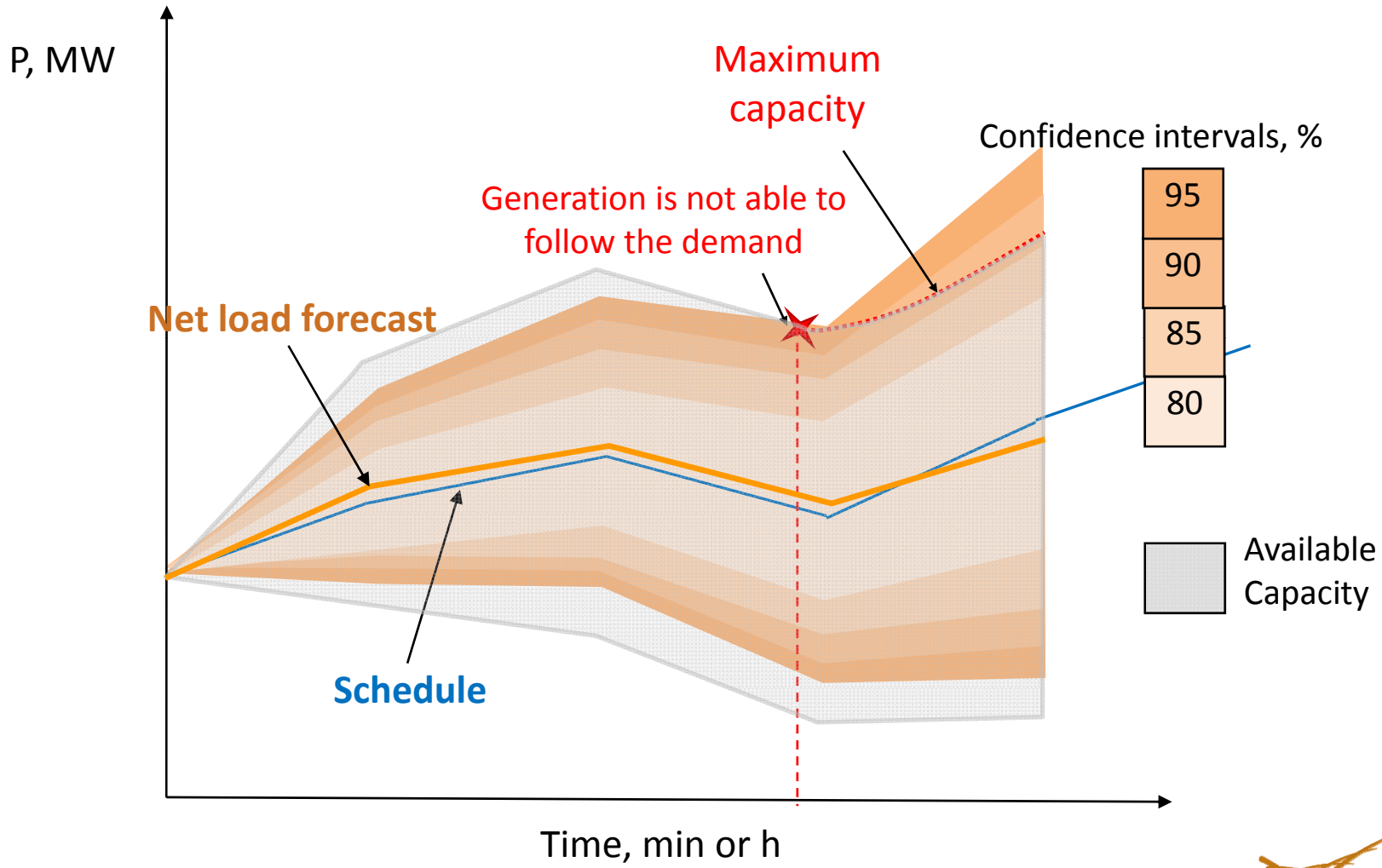
Probabilistic Tool Concept



Net Load =Load – Wind – Solar - Interchange

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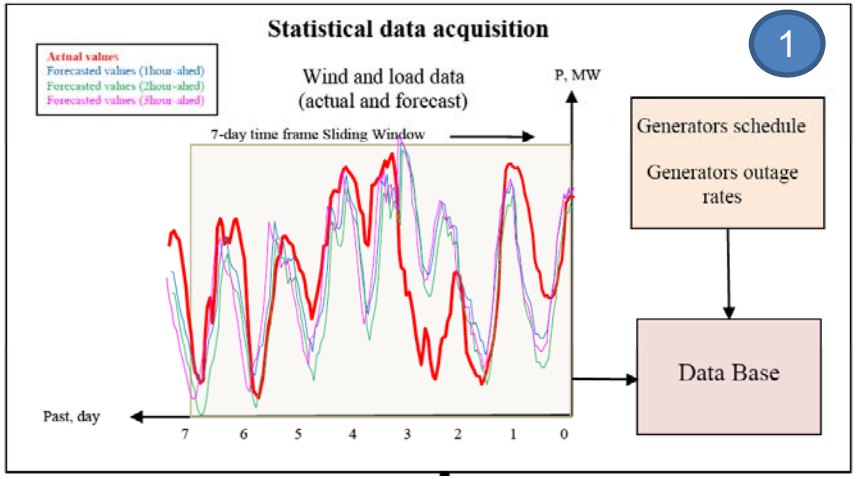
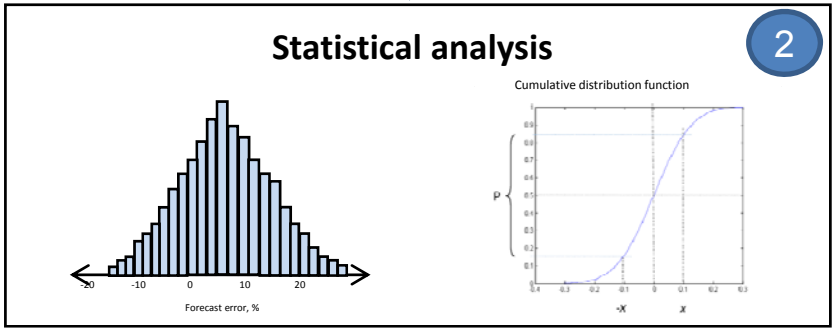
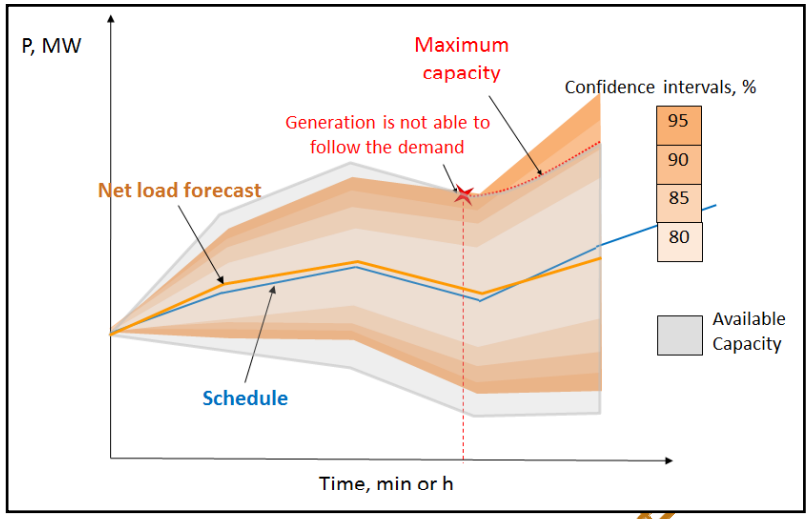
Probabilistic Tool Design





1. Data acquisition
2. Uncertainty assessment through statistical analysis
3. Prediction of future grid balancing requirements for specified time horizons and confidence levels



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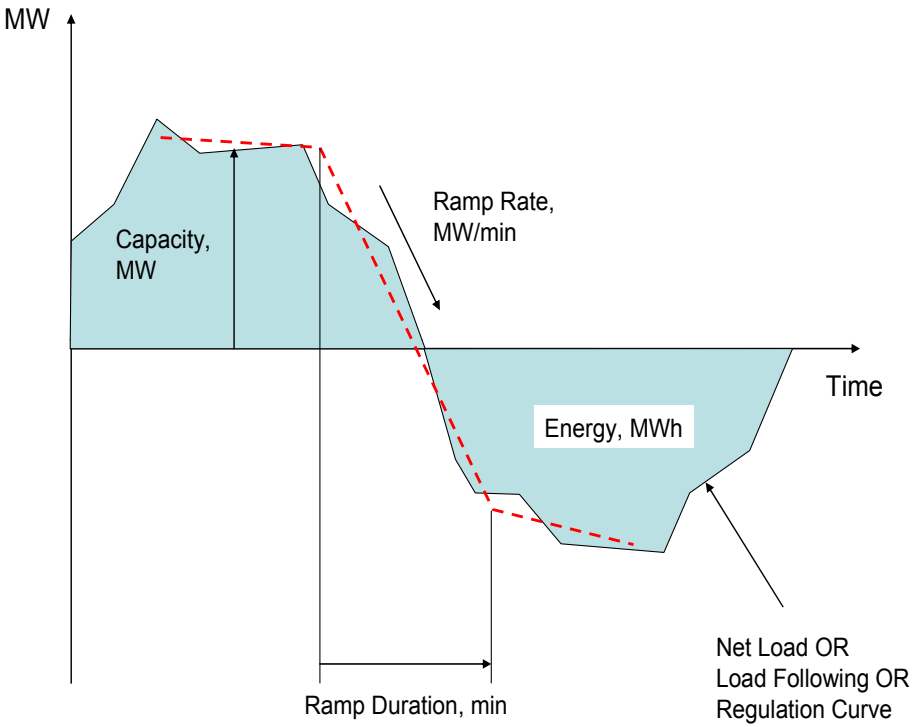
Models for Balancing Requirements Uncertainty: Multidimensional Uncertainty Analysis (1)

- Existing approaches are frequently limited to one dimension of the uncertainty problem – capacity
- But capacity is not a single sufficient descriptor of the problem
- Operational performance of a power system can be demonstrated through four basic metrics, forming the "first performance envelope"
  - *Capacity* (π)
  - *Ramp rate* (ρ)
  - *Ramp duration* (δ)
  - *Energy* (Є)



* Y.V. Makarov, C. Loutan, J. Ma, and P. De Mello. "Operational impacts of wind generation on California power systems," IEEE *Transactions on Power Systems*, vol. 24, pp.1039–1050, May, 2009.

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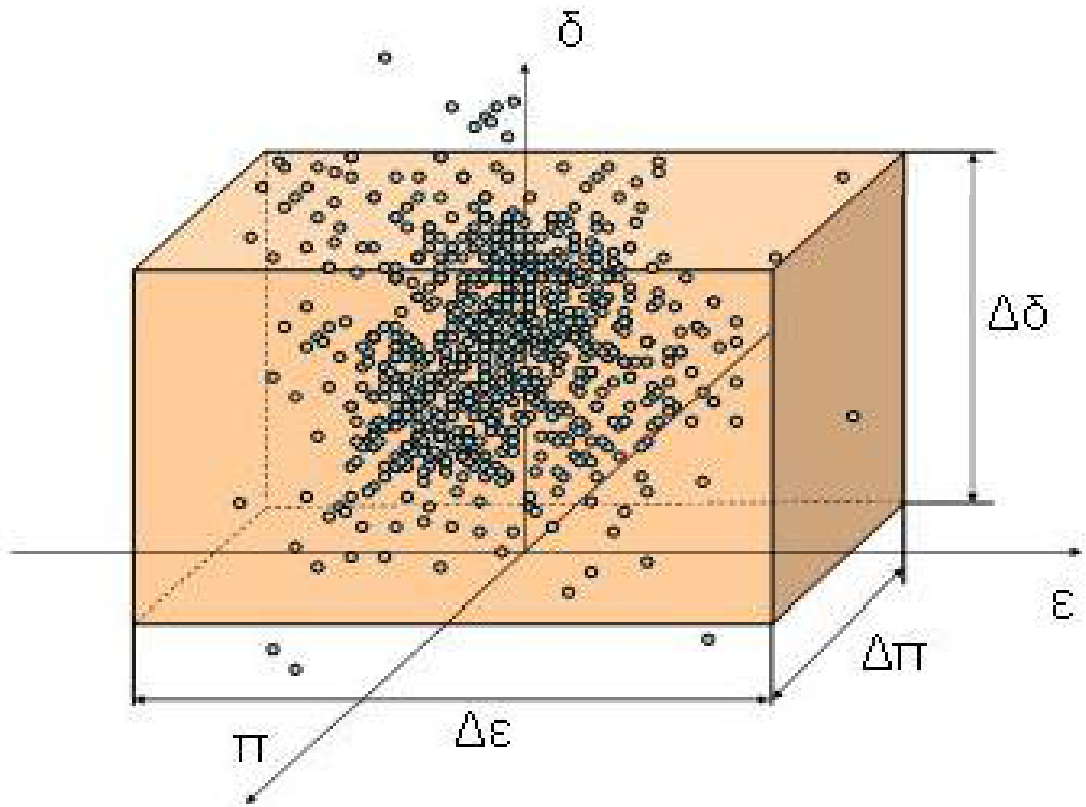
Models for Balancing Requirements Uncertainty: Multidimensional Uncertainty Analysis (2)

- The figure illustrates a plot of three dimensions (Є, π, δ)



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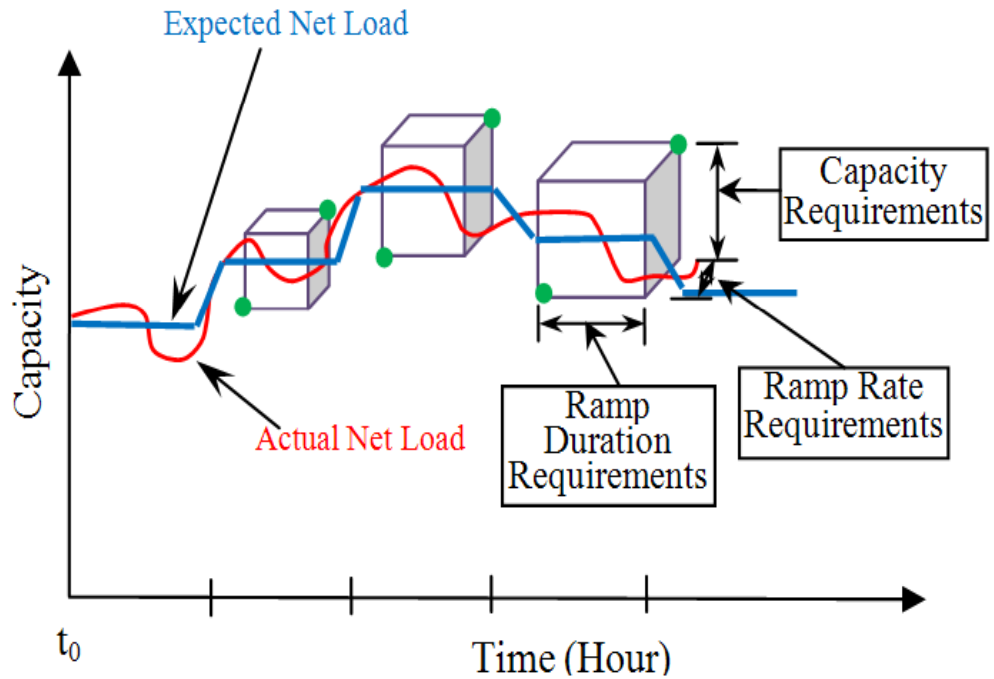
Models for Balancing Requirements Uncertainty: "Flying Brick" Method

- The "flying brick" analyzes time-varying extreme requirements (the worst cases within the uncertainty range) of the look-ahead generation capacity, ramping capability and ramp duration
- The worst combinations of these parameters are found at the vertices of the flying brick
- The objective is to include the capacity, ramp rate, and ramp duration requirements simultaneously and directly into the generation scheduling and dispatch processes



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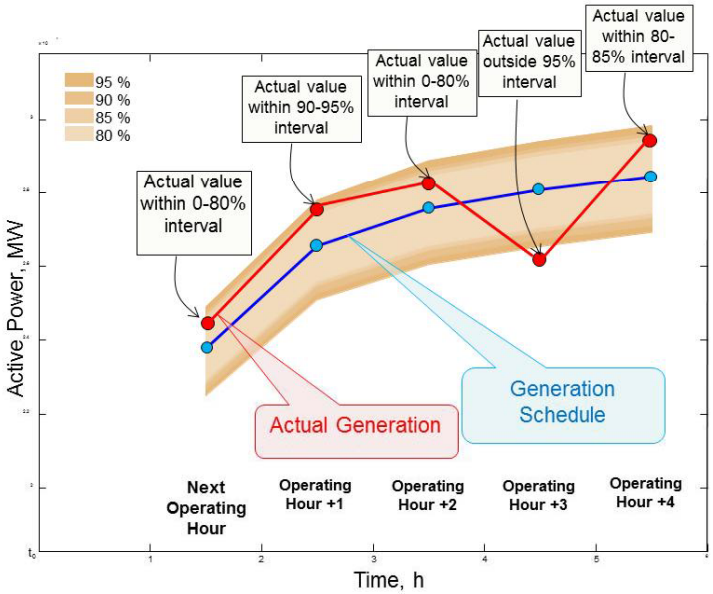
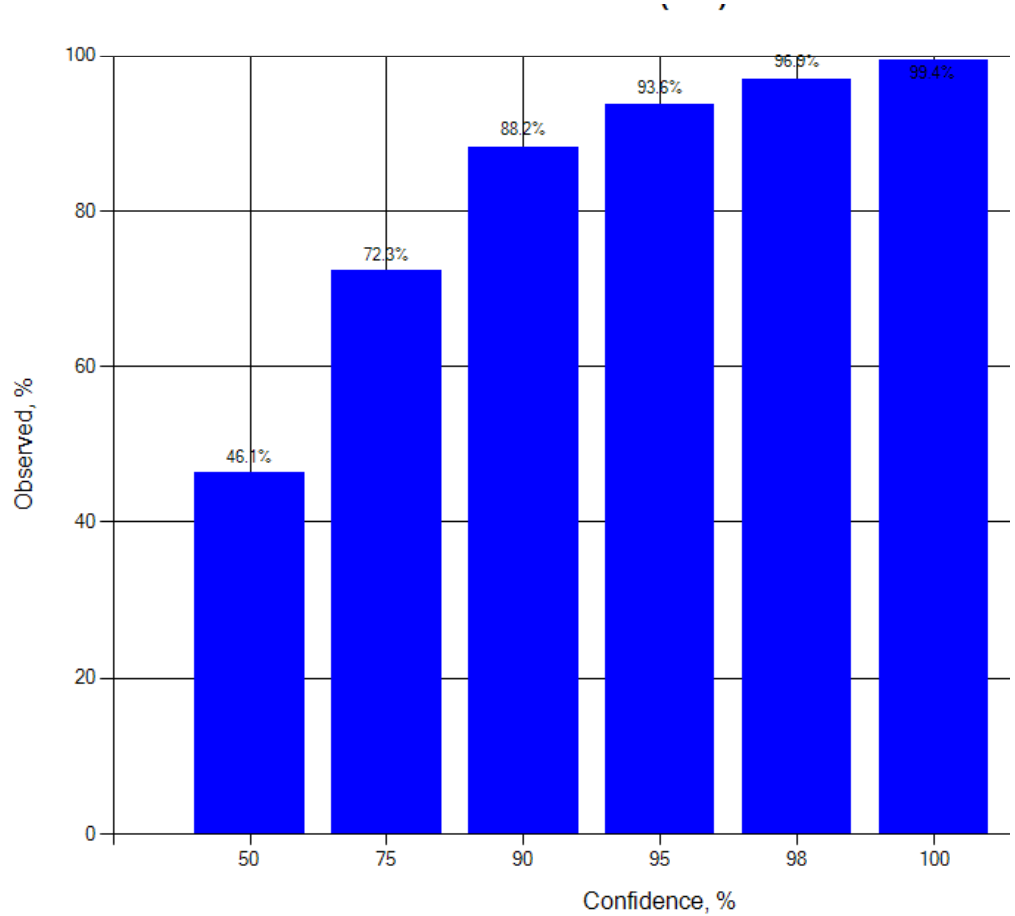
Model Self-Validation





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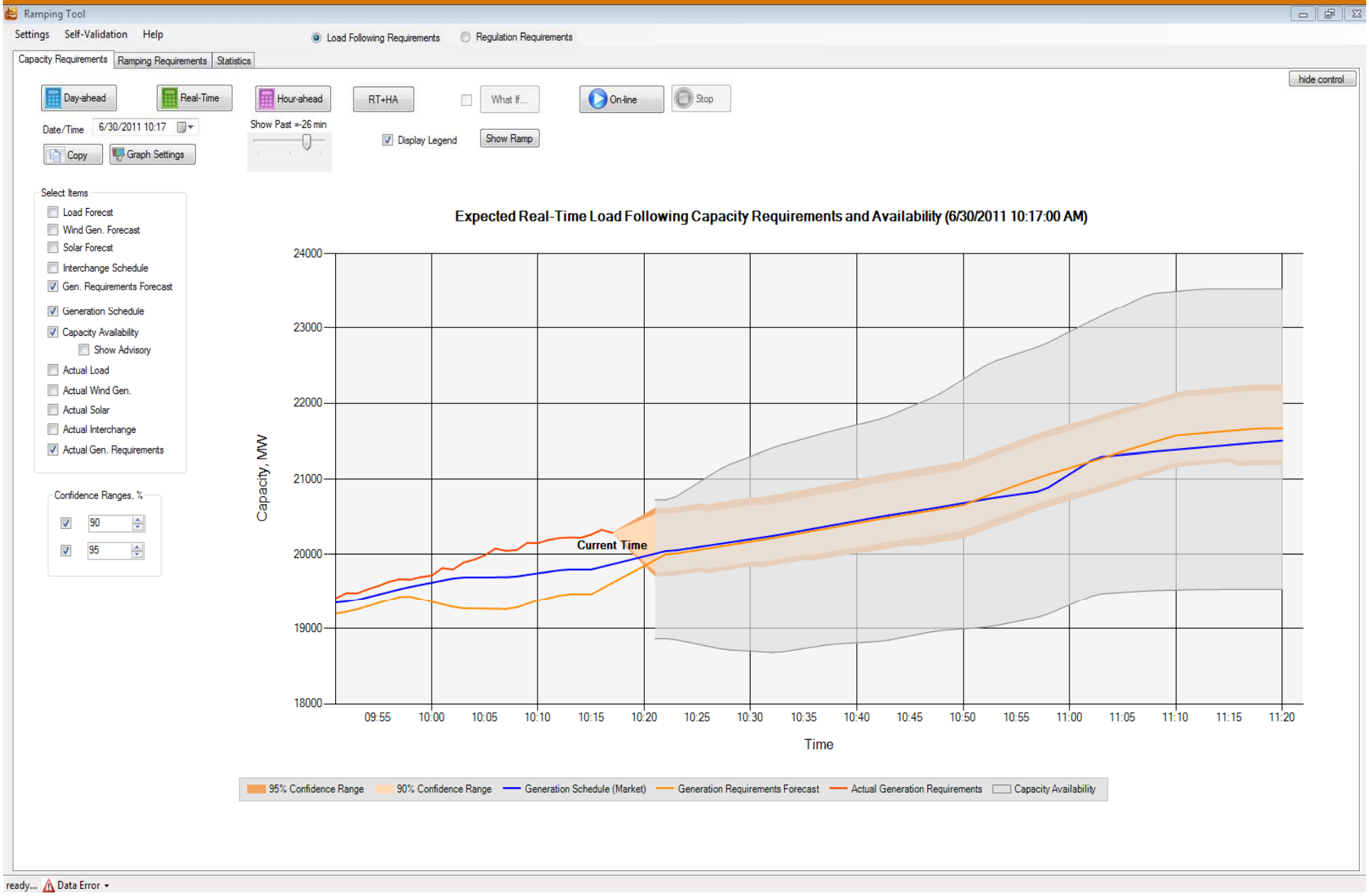
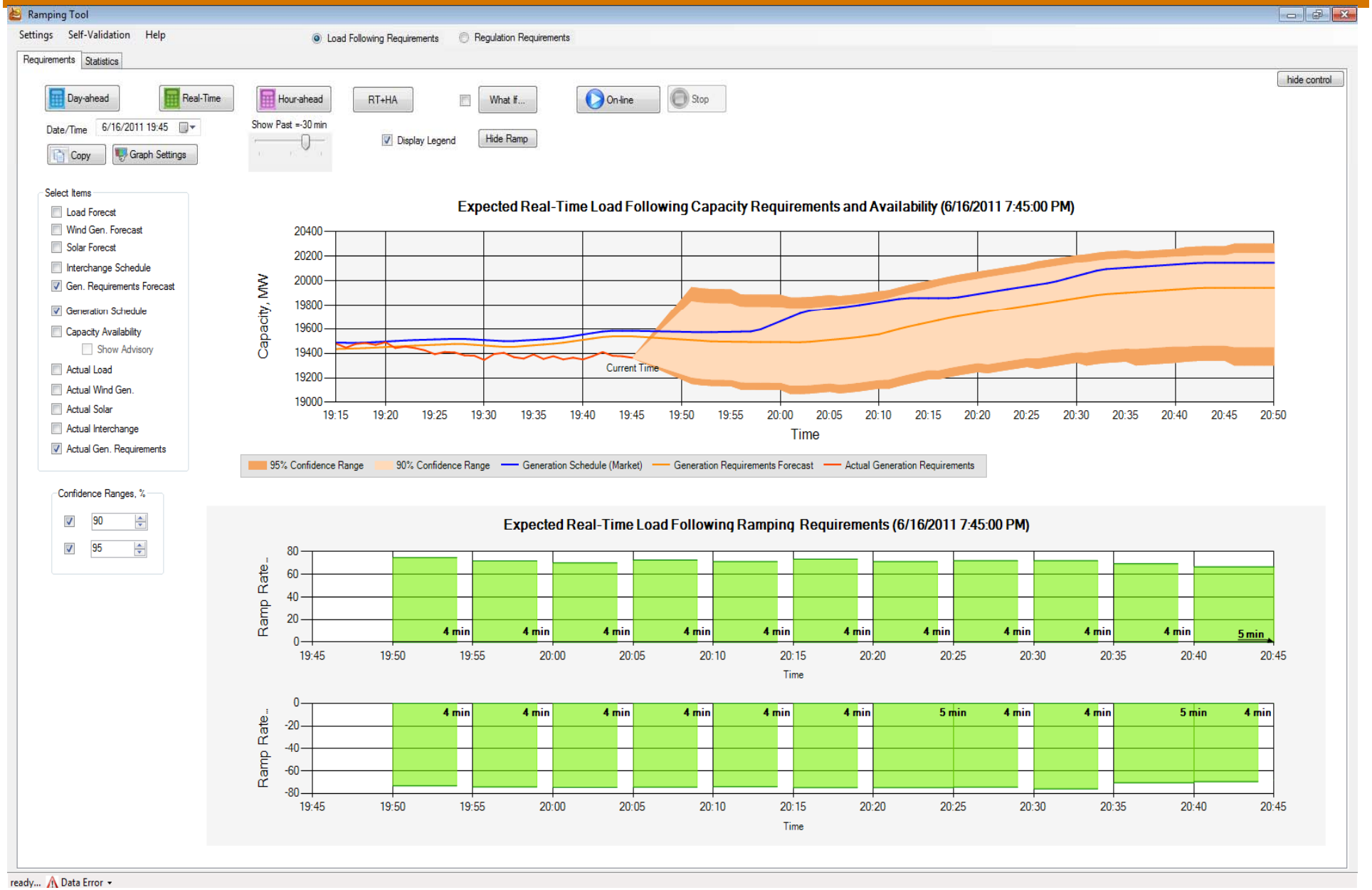
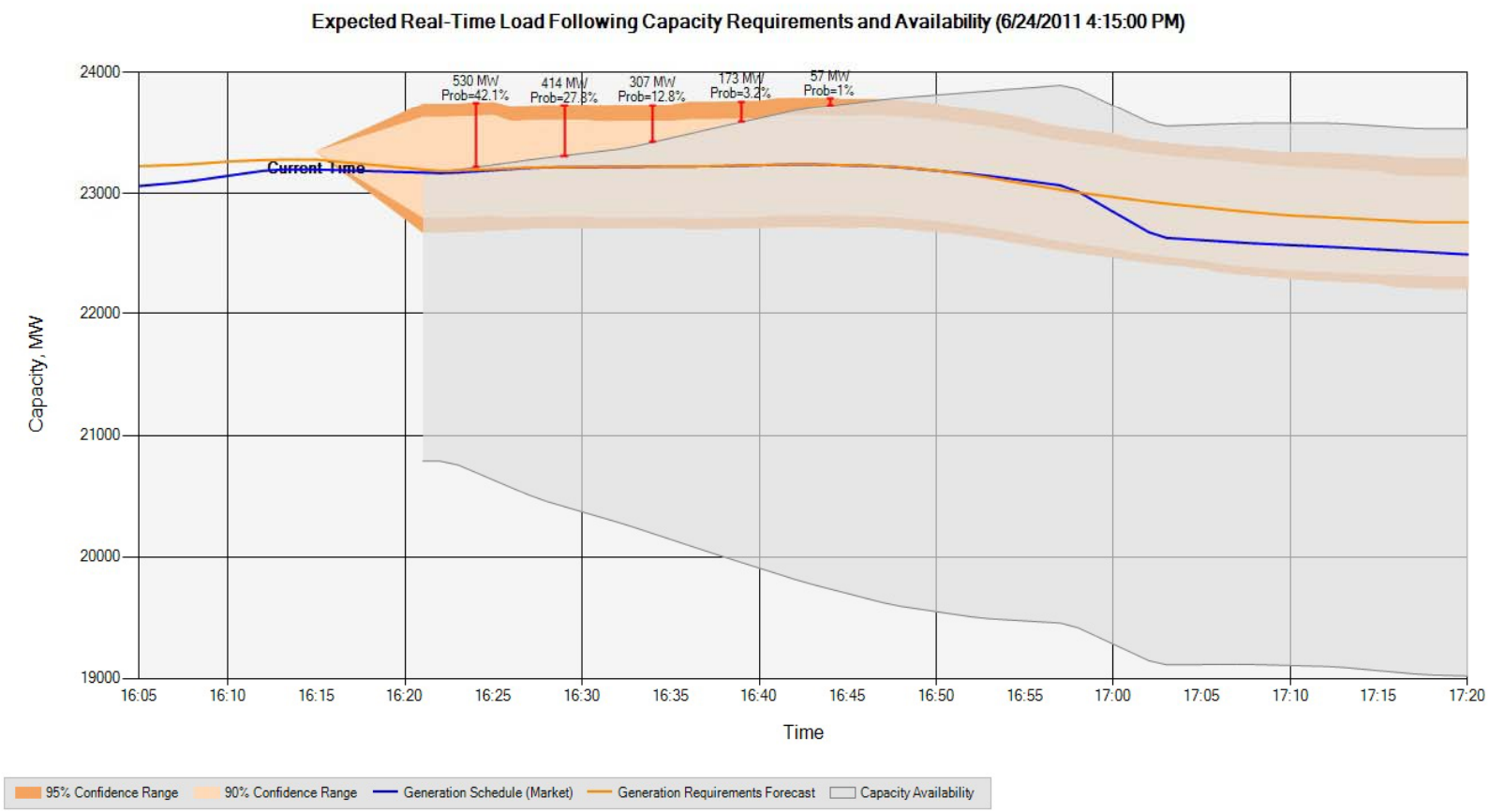
Real-Time Requirements Screen



Real-Time Requirements Screen (2)



Real-Time Screen
(price spike prediction example)



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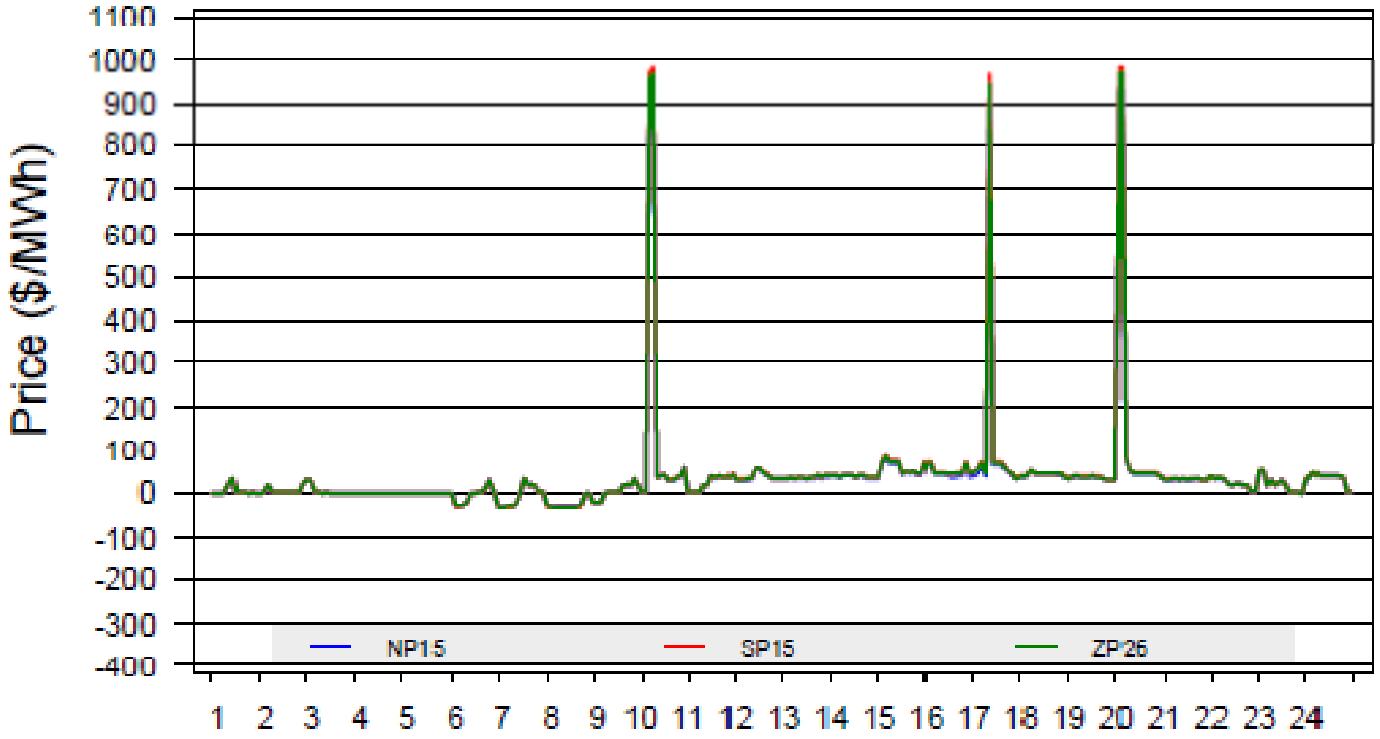
CAISO Real Time Price Monitor, 06/24/2011



*** Available at http://www.aiso.com/Documents/June%202011/DailyMarketWatch_Real-Time_Jun_24_2011.pdf**

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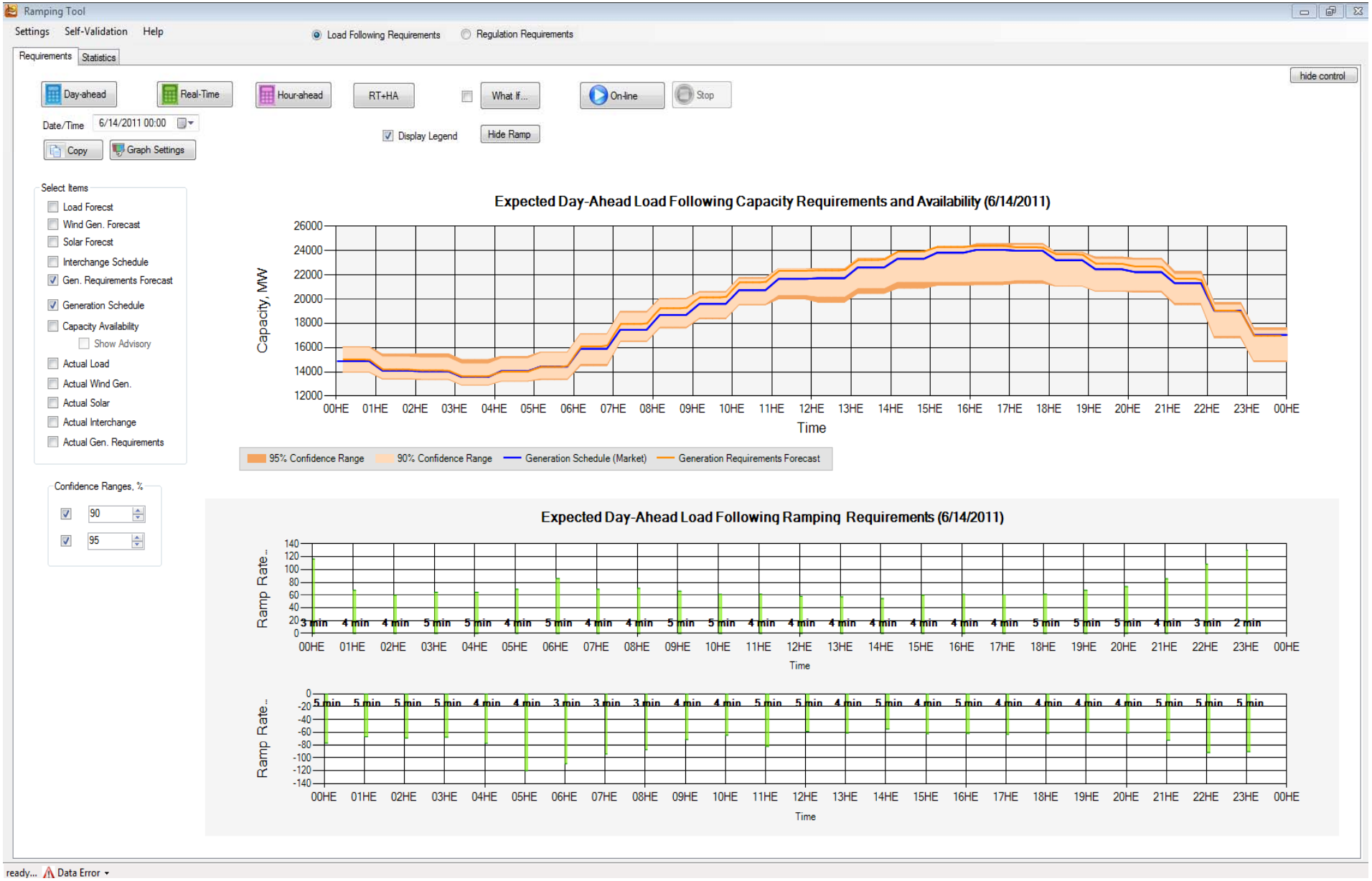
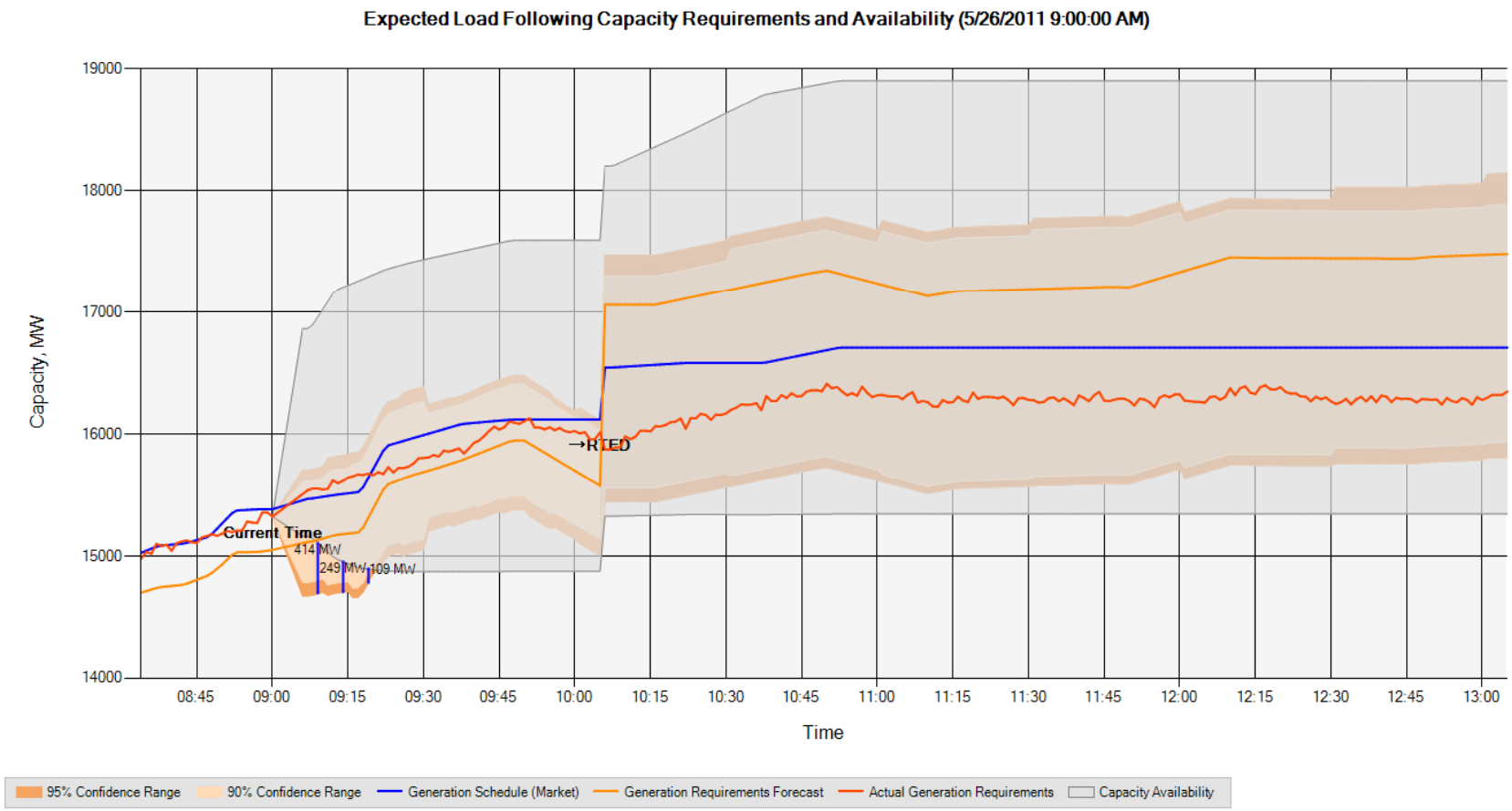
Day-Ahead Requirements Screen



Real-Time + Hour-Ahead Screen



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Summary

- The ramp and uncertainty tool has been developed and deployed at CAISO control room
- The tool received a positive feedback from the CAISO specialists
  - For instance, it has been found that the tool is capable to predict intra-hour deficiency in generation capability
- Future work
  - Develop and test new state-of-the-art uncertainty prediction approaches based on modern statistical methods
  - Feed in uncertainty and ramp information for wind and solar generation weather-based forecasts
  - Investigate the impact of BAAL standard, interchange control and inadvertent interchange accumulations on the uncertainty analysis and propose solutions
  - Implement active and pro-active integration approaches to incorporate uncertainty information back into the unit commitment and dispatch processes
  - Quantify the cost of uncertainty and develop mechanisms for allocating the cost to specific sources and their aggregates