Prediction of Power System Balancing Requirements and Tail Events

PNNL: Shuai Lu, Yuri Makarov, Alan Brothers,
Craig McKinstry, Shuangshuang Jin

BPA: John Pease

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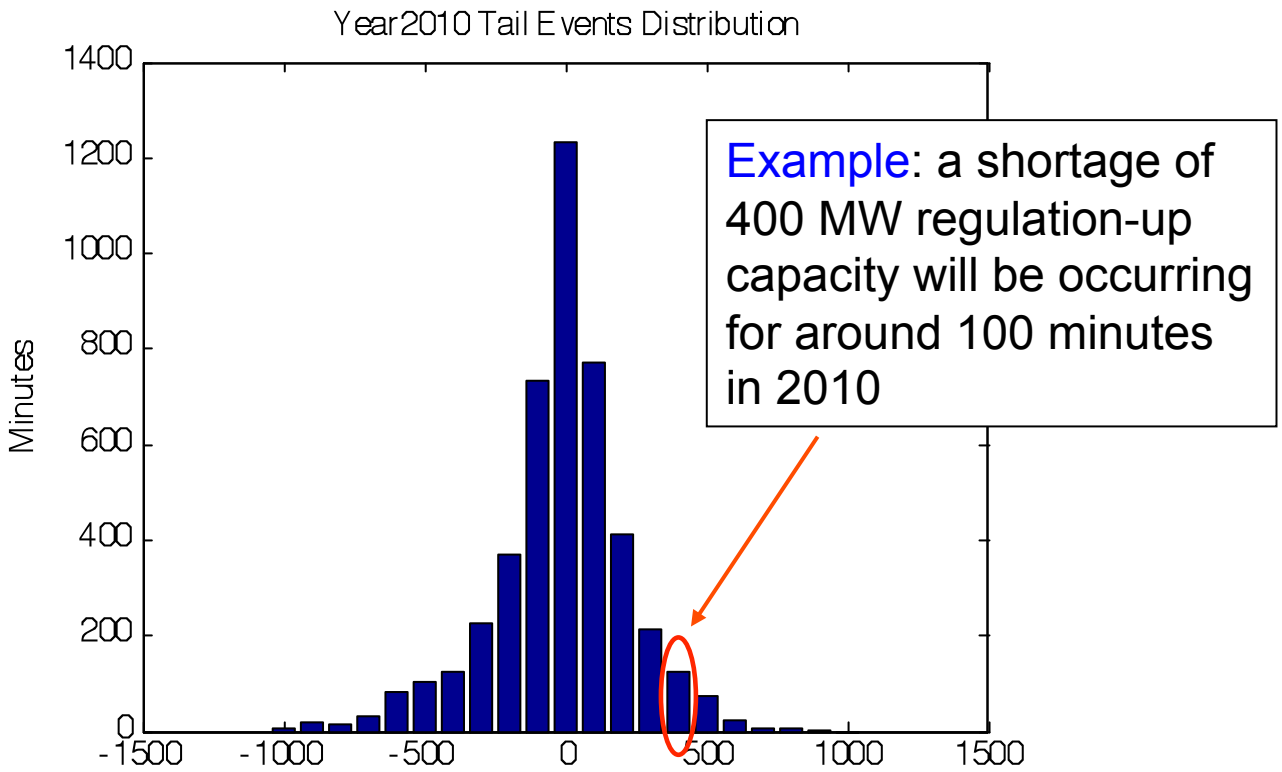
Objectives

- Background: system balancing reserve requirements become more variable with increasing wind and PV penetration.
- Tail event is defined as the cases when balancing reserve is less than potential system imbalance (mismatch between generation and load).
- The project is to answer two questions:
  - How many MW of balancing reserves will be needed, in long term (planning) and real time (operation)?
  - How likely and severe do tail events happen, in long term and real time?

Methodology

- Statistical analysis on future scenarios for long-term strategy
  - Part 1: Distributions showing occurrence frequency versus MW size of system imbalance
  - Part 2: Distributions showing MW balancing requirement and size of tail events, for each hour of a day
- Decision support model for real-time operation
  - Part 3: A model to predict the balancing requirement in real-time, and to provide suggestions on dispatch actions

Methodology Part 1: Distribution of Tail Events (deficiency in balancing reserves)



Remaining Imbalance after the Depletion of Regulating Reserves [MW]

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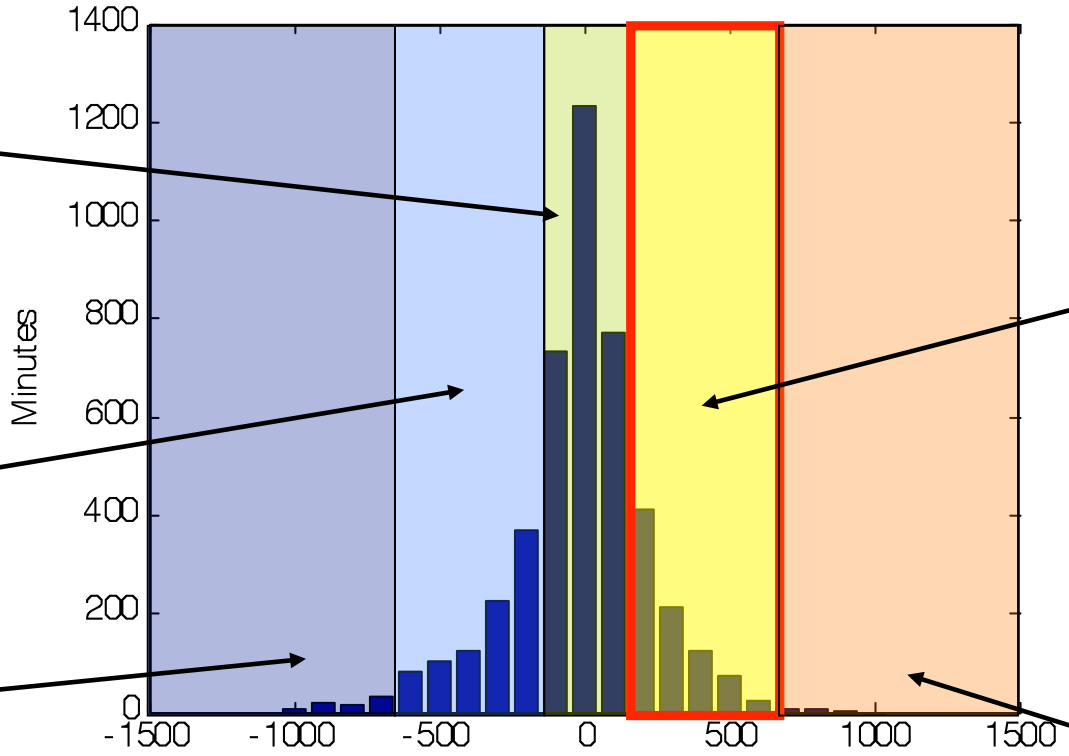
Strategies to Deal with Tail Events

No action needed after the deployment of regulating reserves (variances are small and allowed by CPS)

Use wind curtailment or other strategies

Rely on other BAs to manage the imbalance



Could use contingency reserve (200-600 MW for 850 min over the year)

Rely on other BAs to manage the imbalance

Actual width of each block will be determined by the BA, considering both **reliability** and **economics**.

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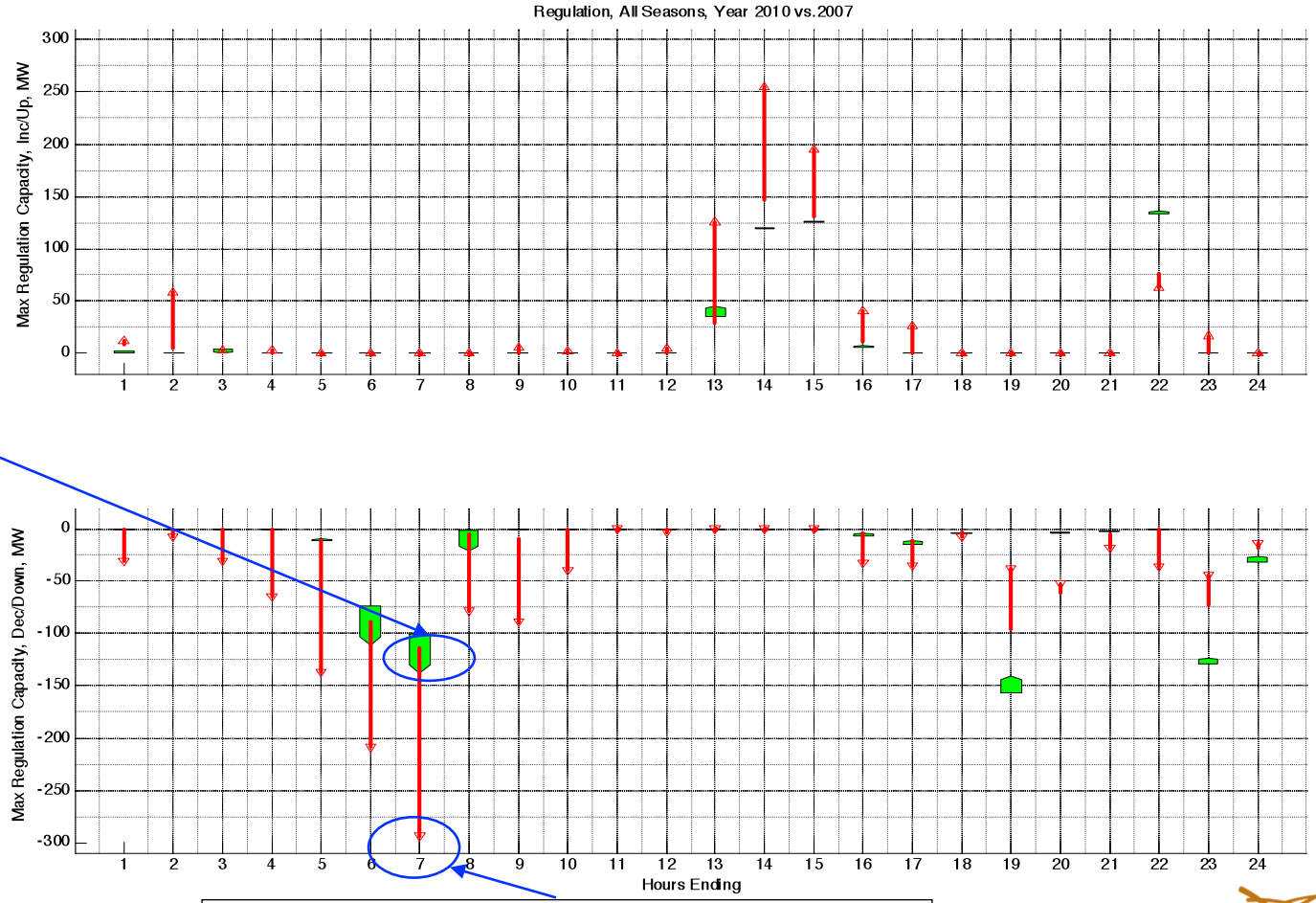
Methodology Part 2: Temporal Distribution of Tail Events



Without wind, deficiency of downward balancing reserve is 120 MW for 07:00 hour

With wind, deficiency of downward balancing reserve is 300 MW for 07:00 hour

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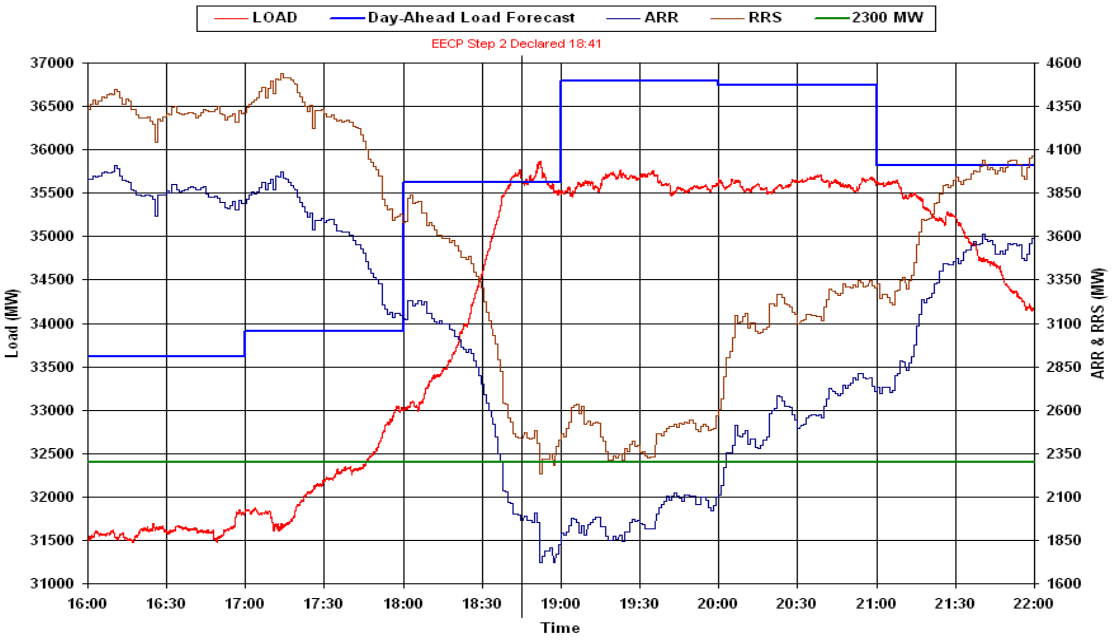
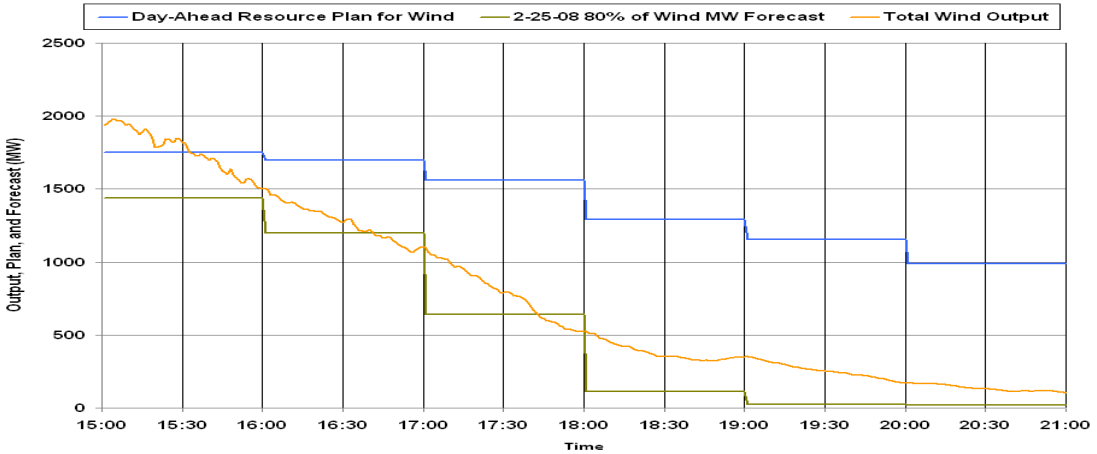
Methodology Part 3: Real-time Decision Support Model

- Build an operational tool that can
  - Predict system imbalance, based on current system information and historical experience
  - Determine the chance and size of tail events
  - Provide real-time decision support to operators

Factors Contributing to System Imbalance





1. Load forecast error
2. Wind forecast error
3. Unexpected loss and unavailability of conventional generation

Source: ERCOT Operations Report on the EECP Event on February 26 2008

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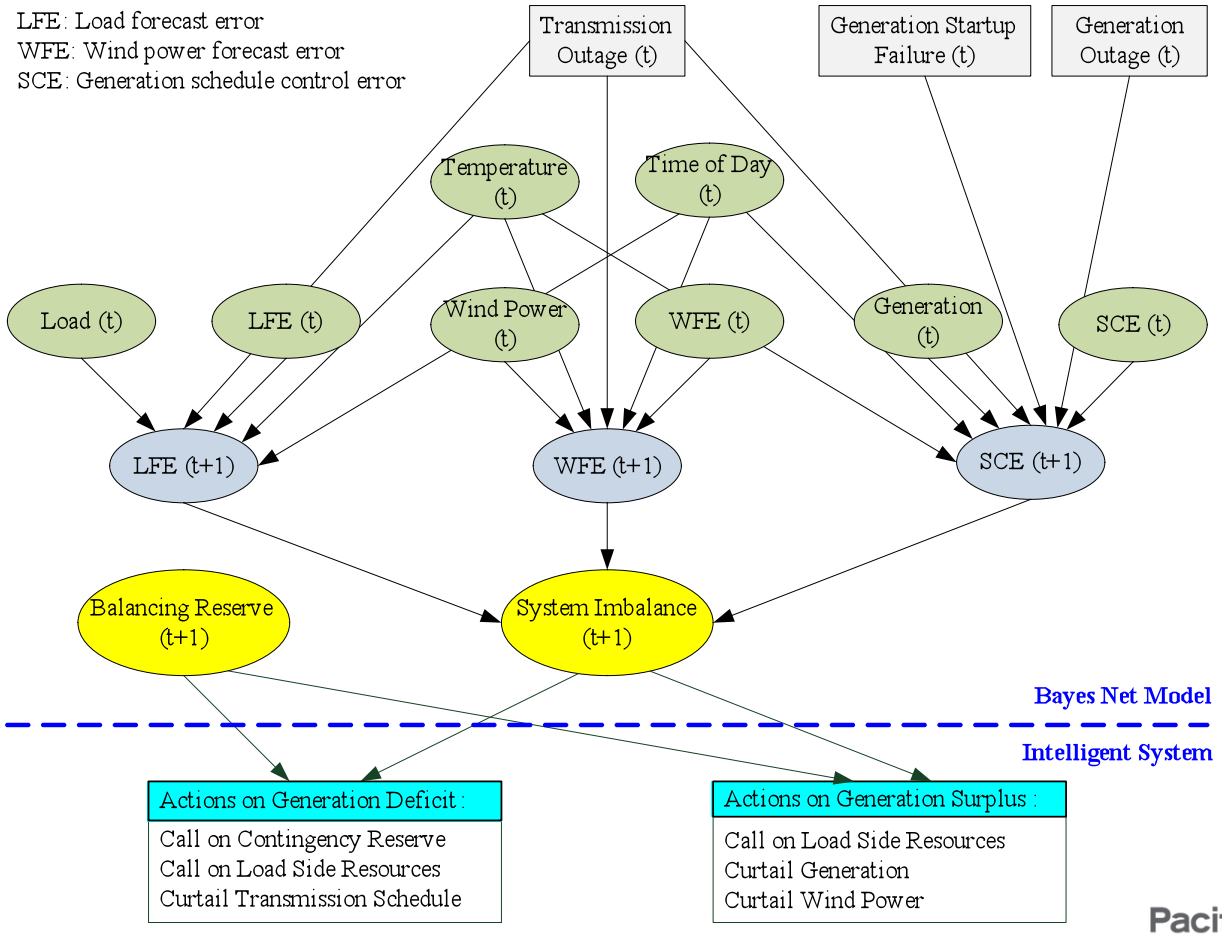
Bayesian Network Model Predicting System Imbalance



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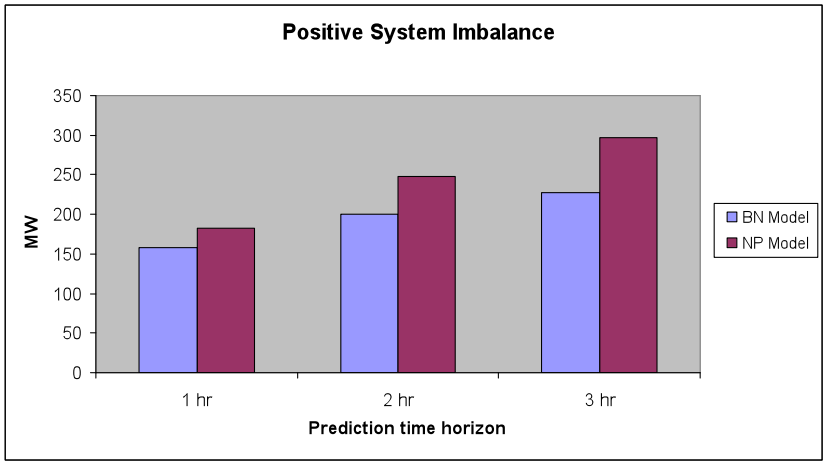
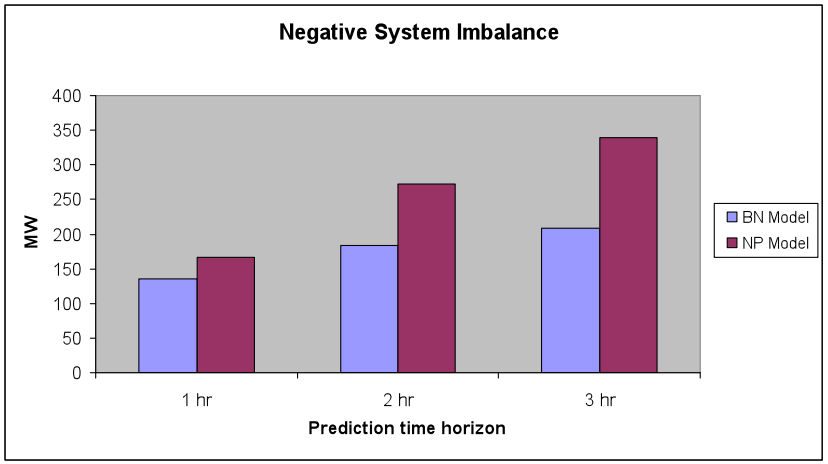
Characteristics of Bayesian Network Model

- Makes good use of prior knowledge (historical data) of the system
- Use current system state as input (conditions) to predict the (conditional) probability of future states
- Convenient to incorporate existing load and wind forecast models
- Easy to include additional independent deterministic factors

System Imbalance Prediction Validation

Mean Absolute Error (MAE) of prediction results from BPA data:



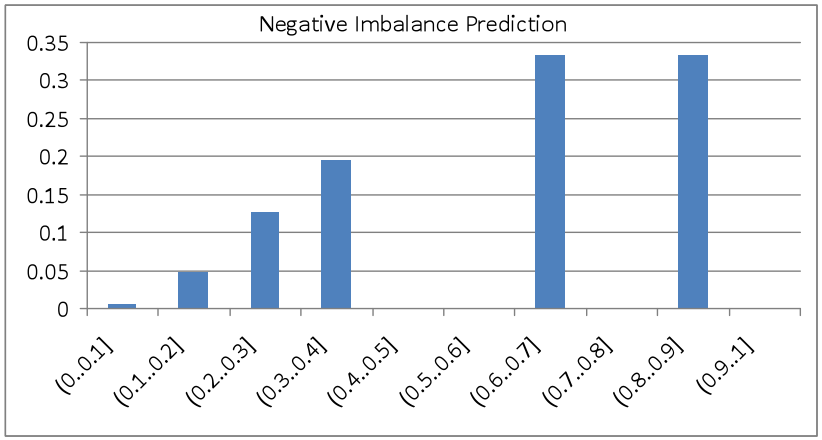


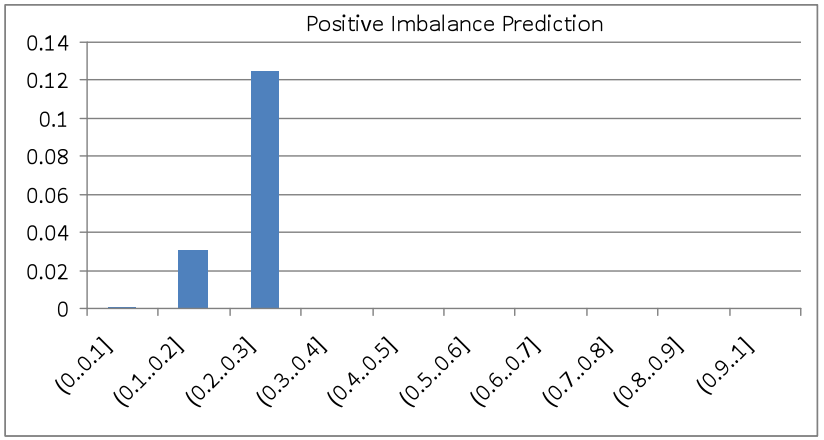
BN Model: Bayesian Net work Model
NP Model: Naïve Persistence Model

Average improvments:16%, 26% and 31% for 1-, 2- and 3-hour forecasts

Tail Event Probability Prediction Validation

Predicted probability of tail events vs. chance of tail events actually occurred





Vertical axis: percentage of cases when tail events actually occurred
Horizontal axis: the probability of tail events predicted by the model (for 1 hour prediction)

Conclusion

- Statistical analysis on future scenarios provides:
  - Understanding of the issue: degree of imbalance to be seen, duration, occurring hours
  - Estimate of severity of tail events corresponding to a certain reserve level
  - Establish (long term) reserve requirement for future wind and load scenarios
- Model for real-time balancing requirements provides:
  - Estimate of needed balancing reserve
  - Chances of tail events in the following hours
- Similar analysis and model can also be applied to determining ramp requirements.

Future Work

- Include generation and transmission outage on system imbalance model
- Make the model adaptive to changing system composition, i.e. increasing wind capacity, load and generation, through linear projections or statistical simulations on future scenarios
- Incorporate system operation guidelines and rules to extend the model for decision-making support
- Online calibration of the model

Thank you!

- Questions? Please contact:

- Shuai Lu
- Email: shuai.lu@pnnl.gov
- Phone: 509-375-2235