Renewable Integration Study Next Steps

Mark Rothleder
Director, Market Analysis and Development

Working Group Meeting
October 7, 2011

PURPOSE AND PROCESS

Mark Rothleder

Purpose and Process

- Identify operational requirements and bound potential needs to be prepared for the changes it the fleet
- Evaluate alternatives to meeting the identified operational requirements and needs
- Incorporate results from LCR/OTC studies into 33% study work
- Advisory team will review, guide and prioritize work
- Objective is to complete sensitivity analysis work by December 2011 and perform final study work in Q1 2012

Current Advisory Team

- Jack Ellis
- Udi Helman (Brightsource)
- Dariush Shirmohammadi (CalWEA)
- Keith White / Kevin Dudney (CPUC)
- Bob Fagan / David Peck (DRA/Synapse)
- Antonio Alvarez (PG&E)
- Robb Anderson (SDGE)
- Mark Minick (SCE)
- Kevin Woodruff (TURN)

Next Steps Schedule

Next Step	Target Schedule
Working group kick-off	October 7, 2011
Requests for additional study work	October 14, 2011
Triage and prioritize requests	October 19, 2011
Perform priority analysis and review results	October - December, 2011
Complete LCR/OTC analysis	December, 2011
Scope final study work	January 2012
Perform final study work	January 2012-March 2012
Final results	March 2012

REVIEW OF METHODOLOGY AND RESULTS

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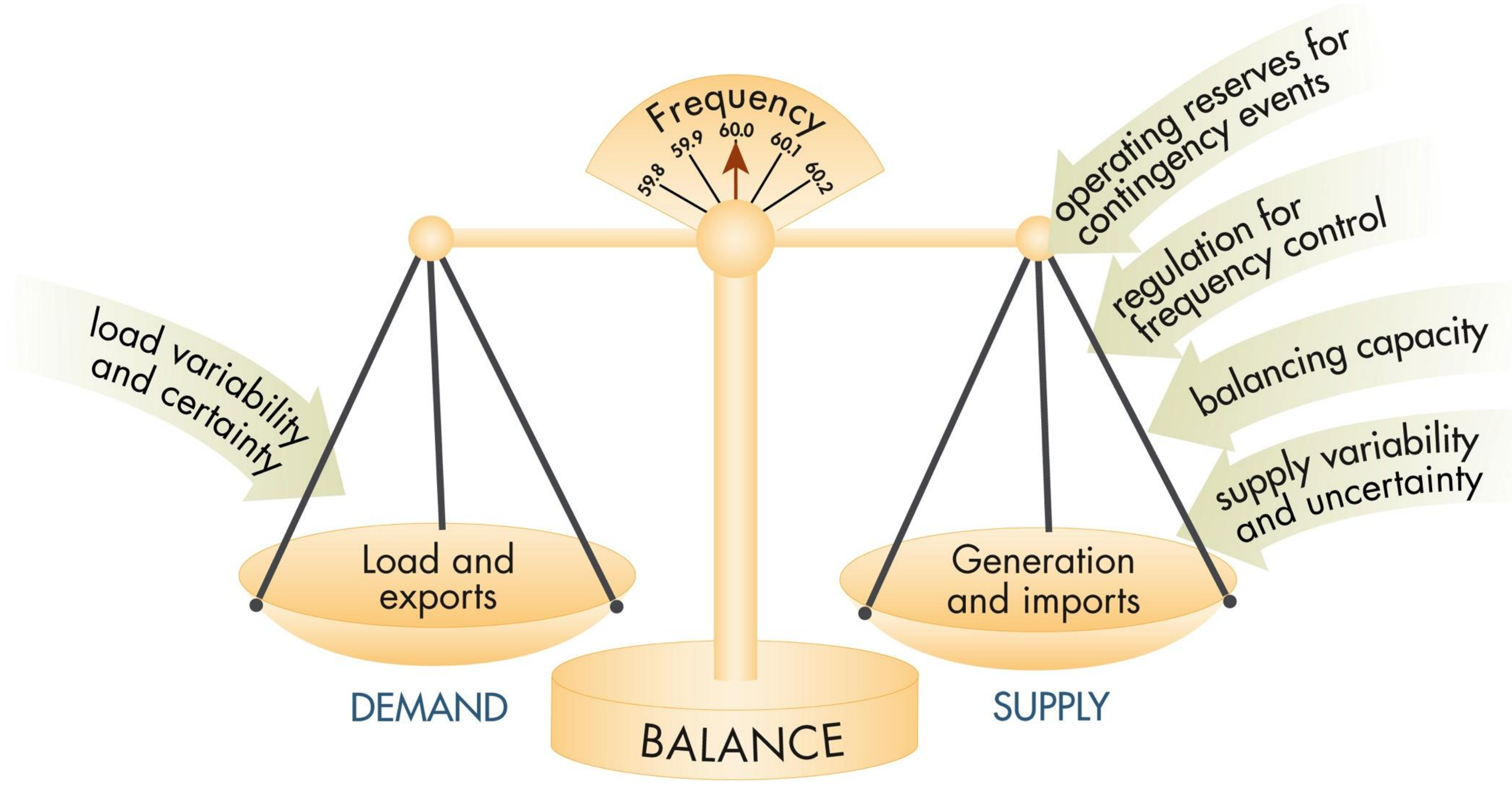
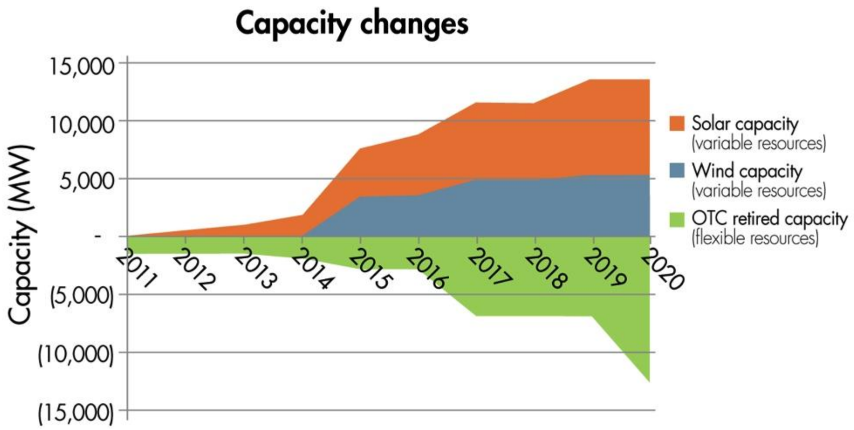
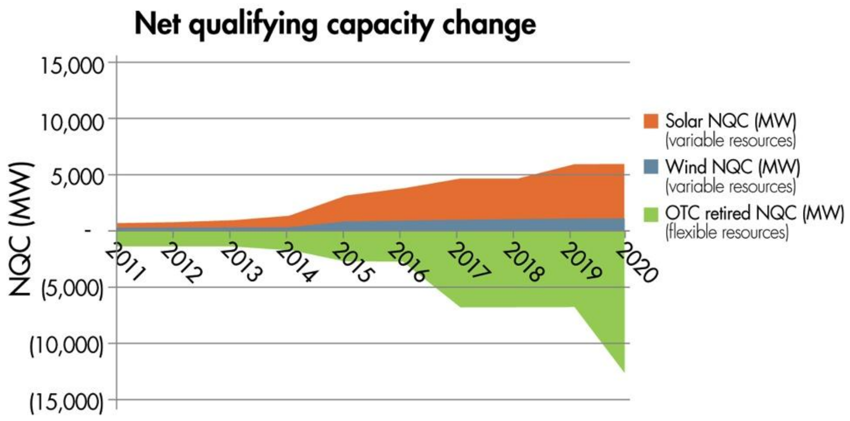
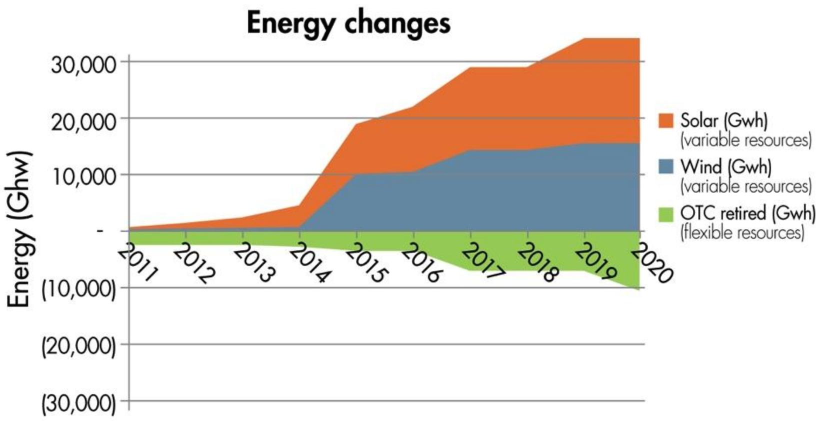
Electricity is produced, delivered, and consumed at the speed of light while balance must be maintained.



Supply variability and uncertainty will increase while the flexible capability of the fleet is decreases

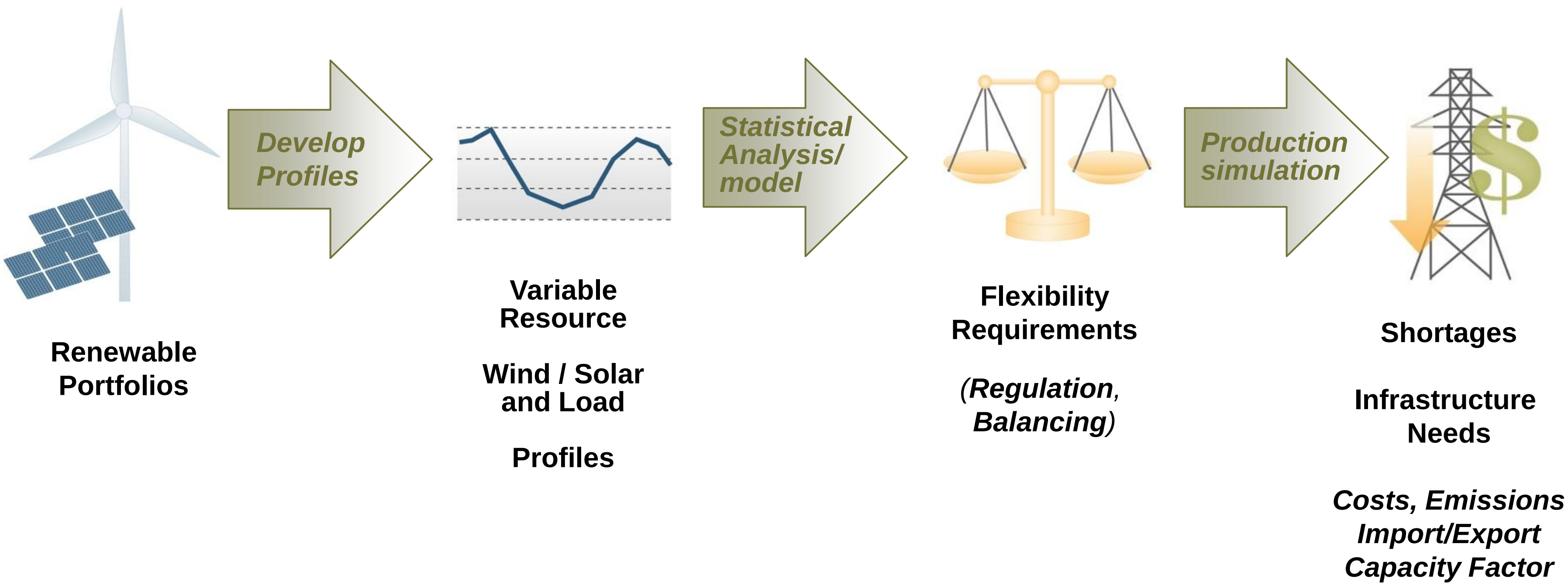






- Operational requirements for flexible capacity will approximately double due to increase of variable resources
- Approximately 15% of the fleet’s flexible capability will retire by 2020

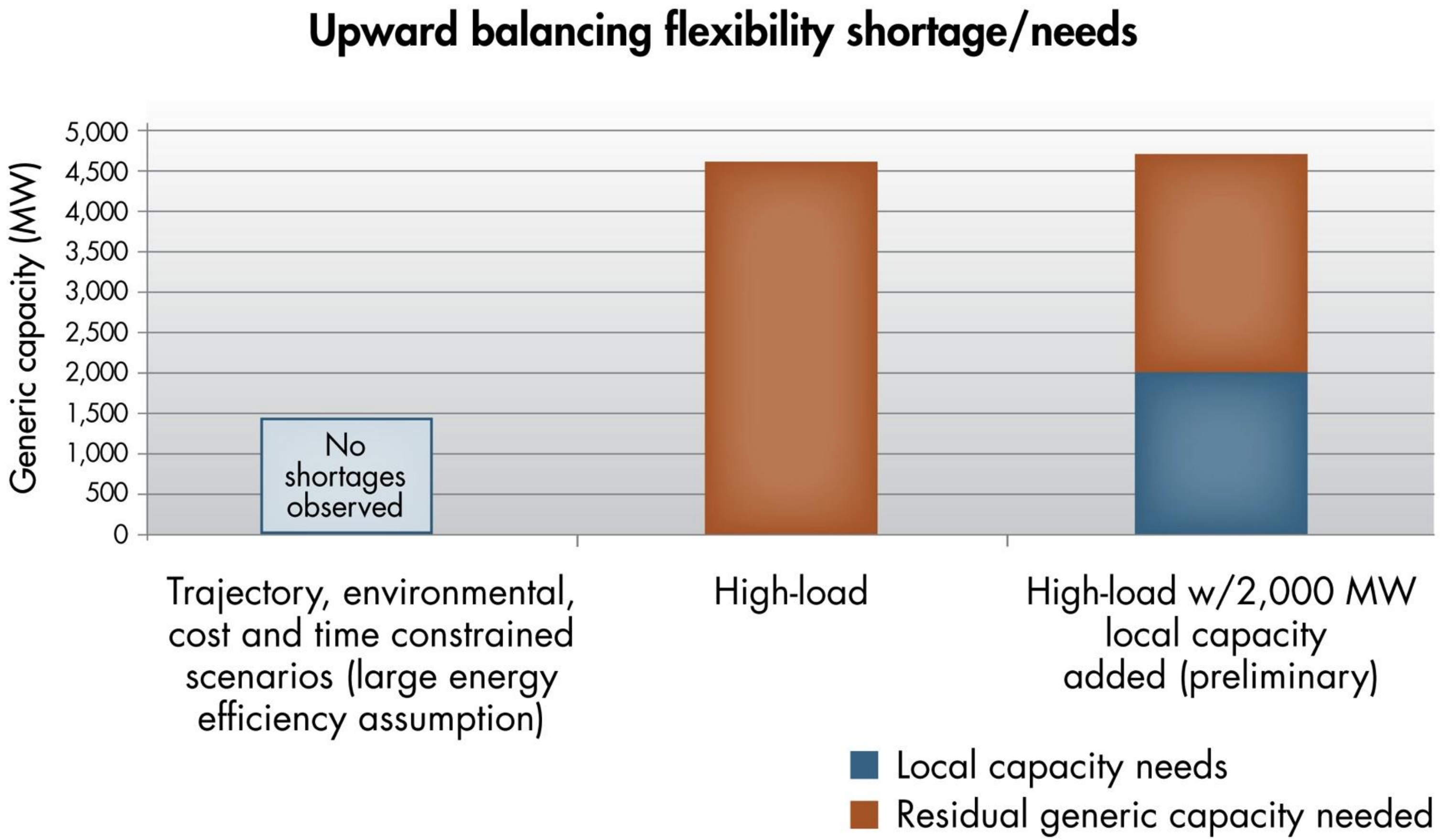
Renewable integration study process quantifies operational requirements and evaluates fleets ability to meet operating requirements.



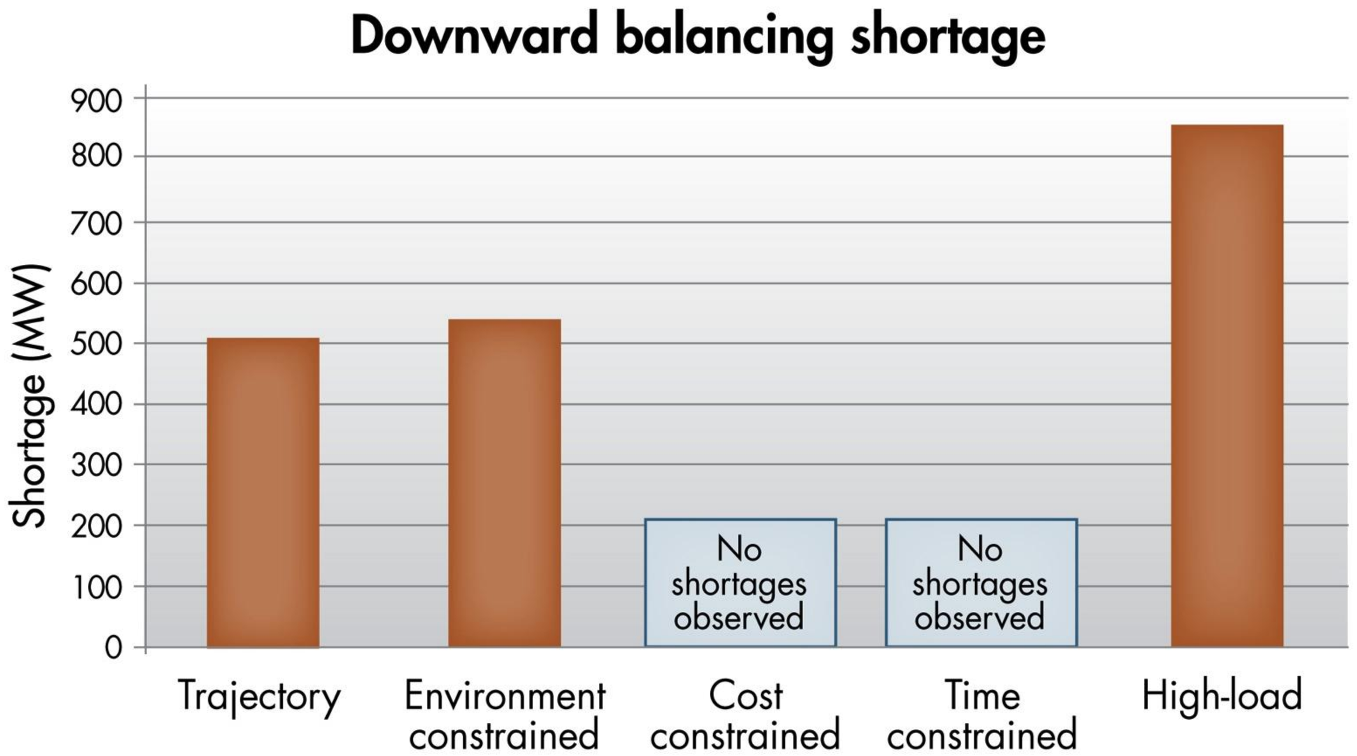
33% scenarios in 2020 cover range renewable and load conditions.

Case	Case Title	Description
1	33% Trajectory	Based on contracted activity
2	Environmental Constrained	High distributed solar
3	Cost Constrained	Low cost (wind, out of state)
4	Time Constrained	Fast development (out-of-state)
5	20% Trajectory	For comparison
6	33% Trajectory High Load	Higher load growth and/or energy program under-performance
7	33% Trajectory Low Load	Lower load growth and/or energy program over-performance

Potential need for 4,600MW of upward flexible resources observed in the high-load scenario.



Out of approximately 3,500 MW downward balancing requirements, observed some hours of potential shortages.



Note: Downward balancing may be more effectively and efficiently managed using curtailment or storage rather than less economic dispatch of flexible resources to higher level to maintain downward flexibility

ADDITIONAL ANALYSIS OF RESULTS

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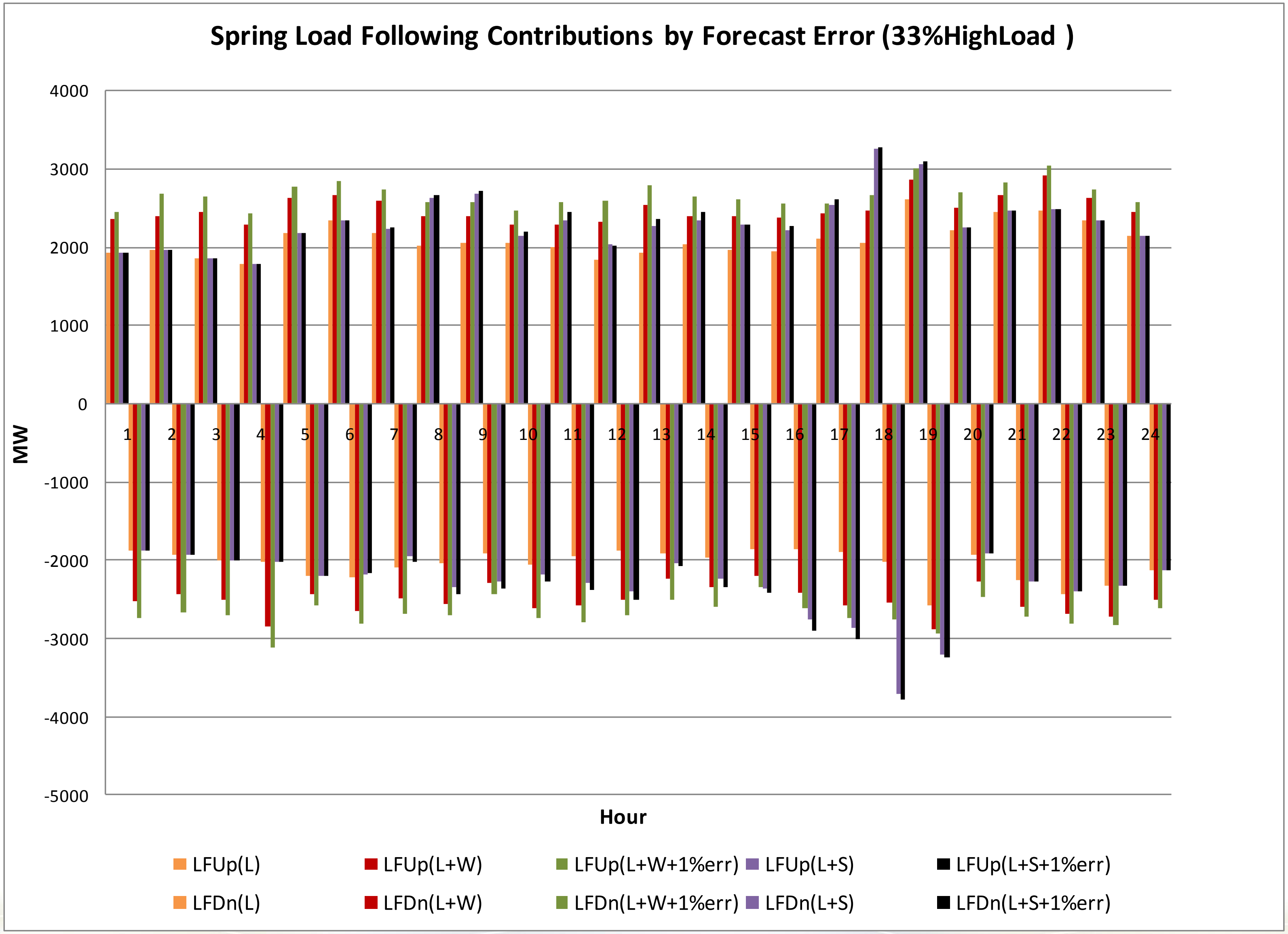
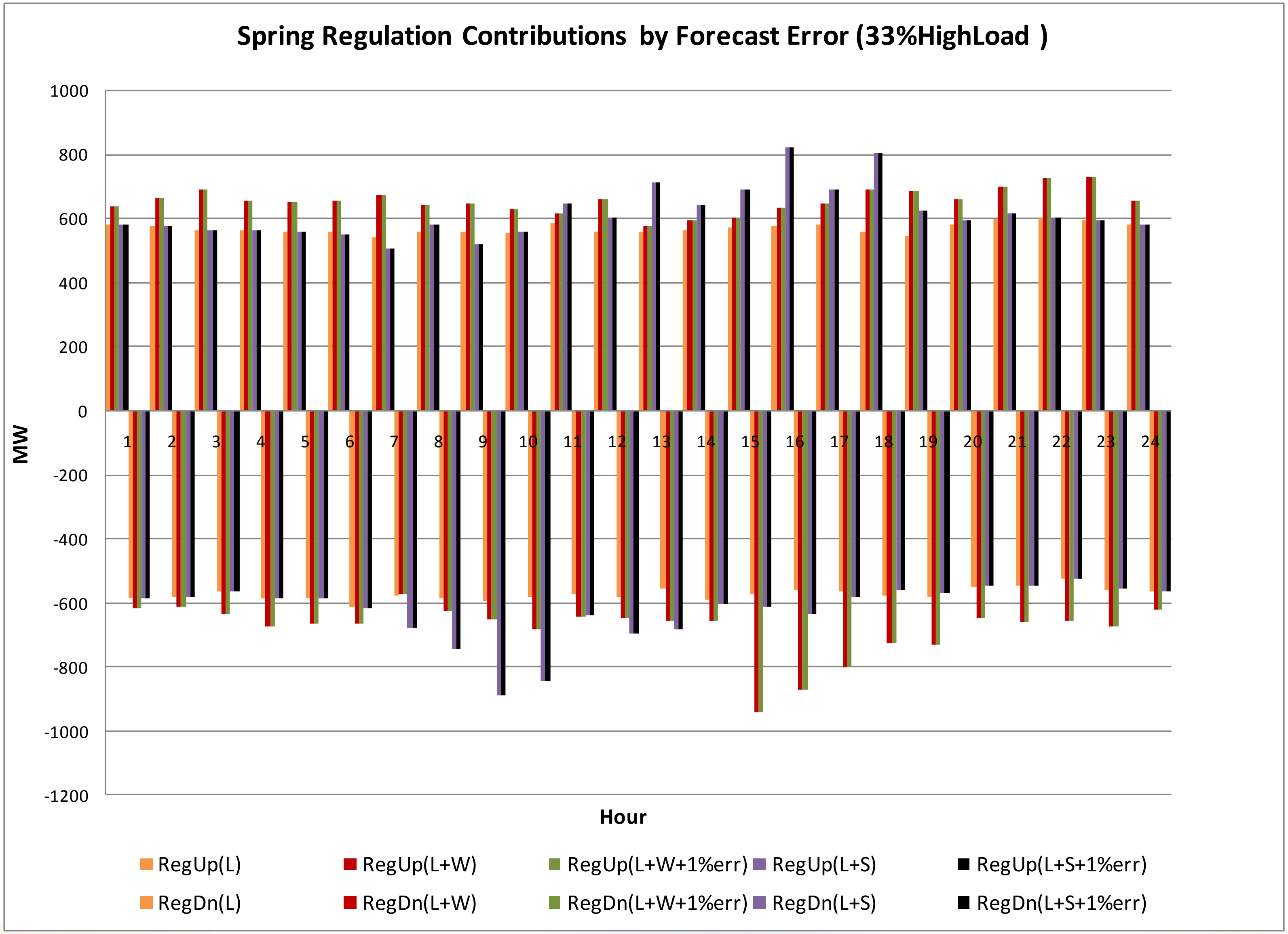
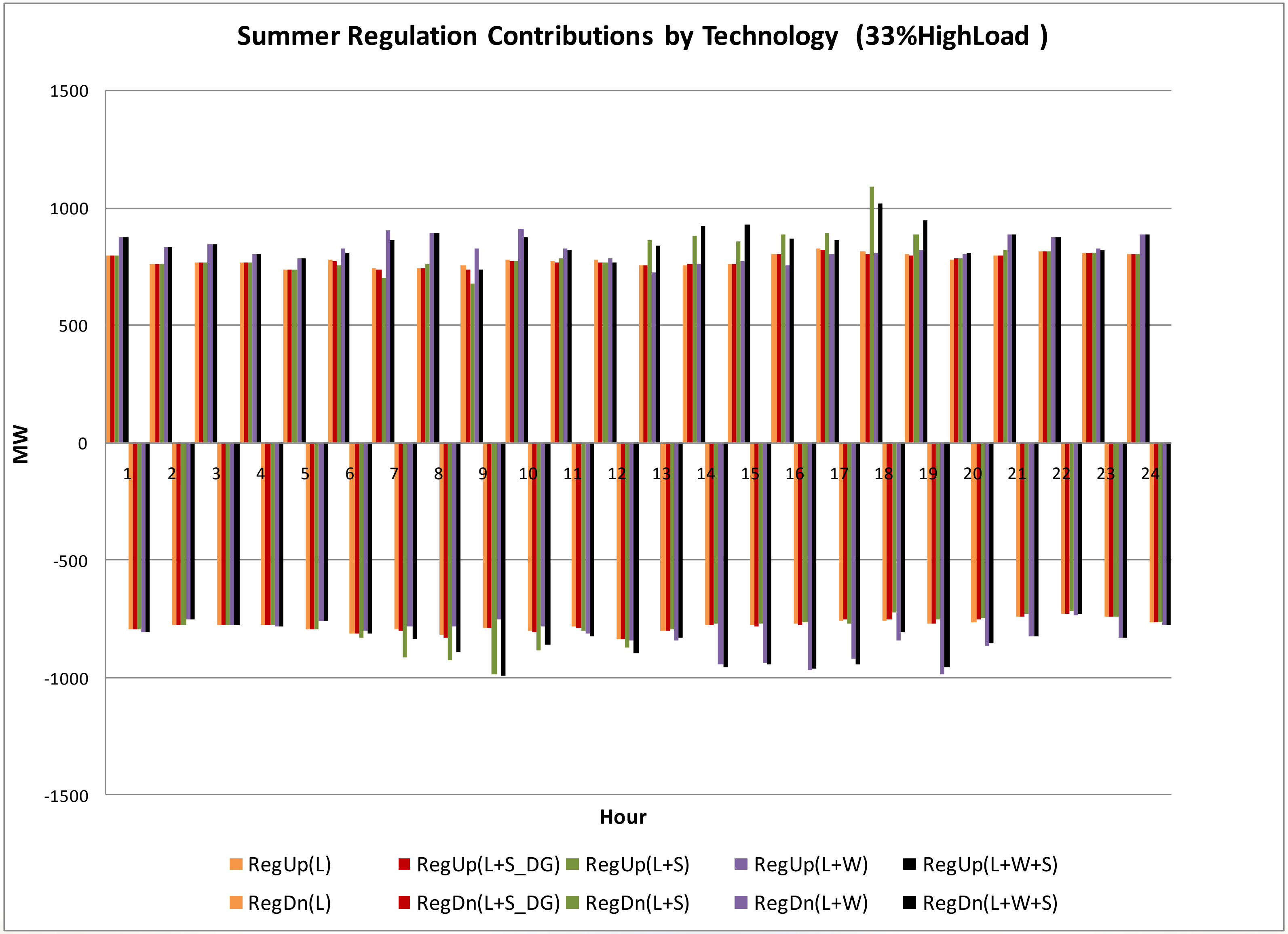
Decomposition of the operational requirements (1)



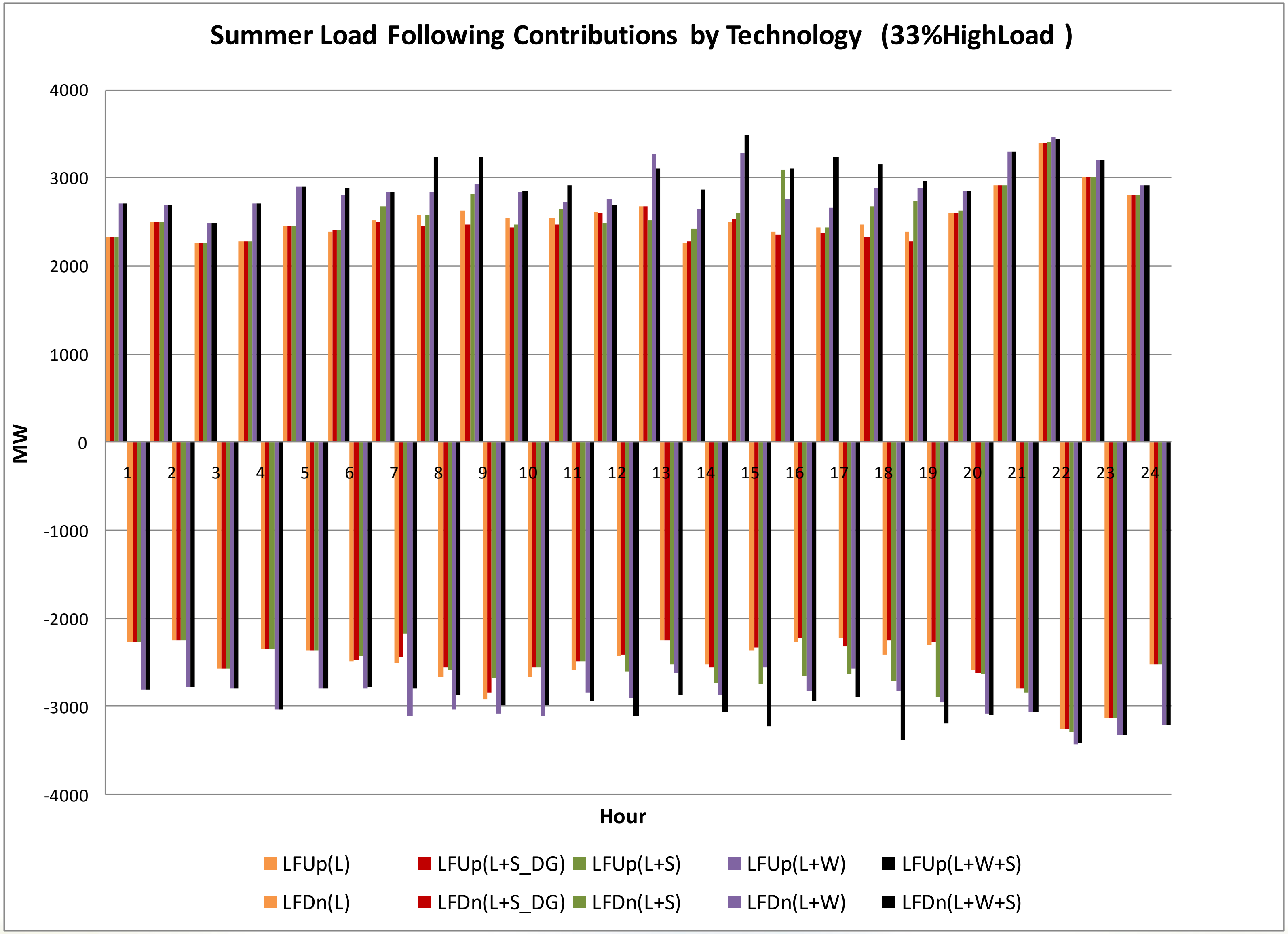
Decomposition of the operational requirements (2)



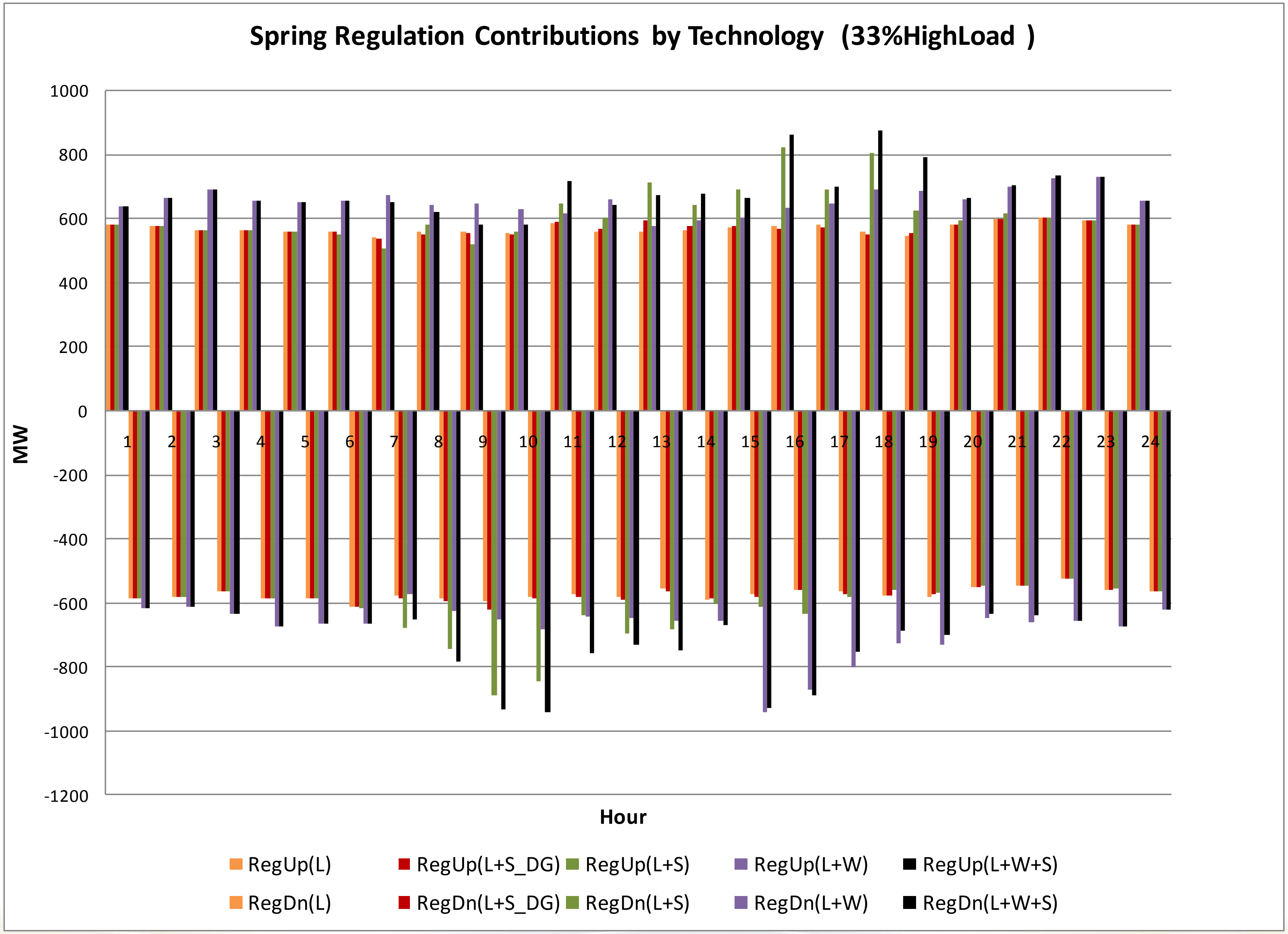
Decomposition of the operational requirements (3)



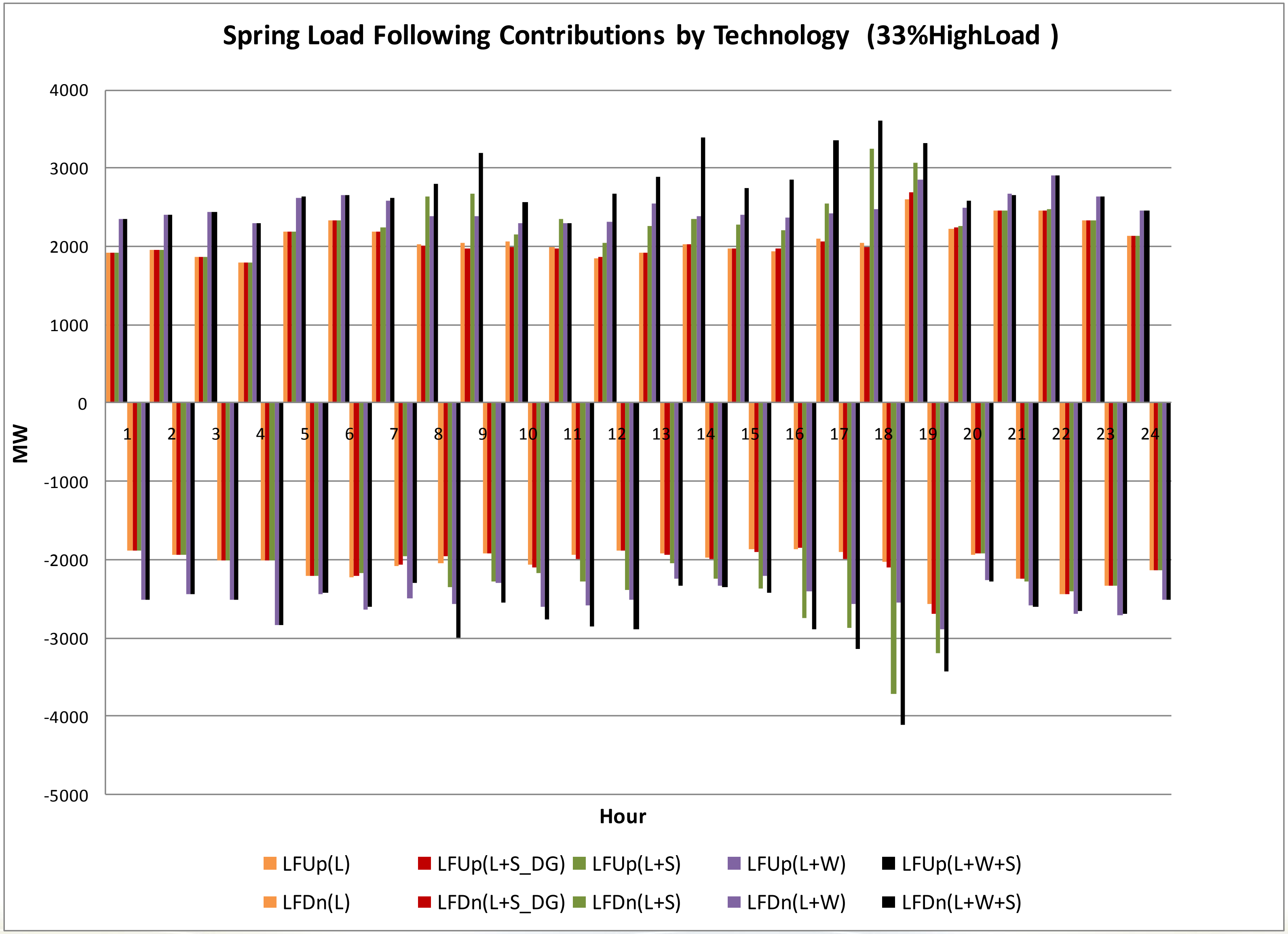
Decomposition of the operational requirements (4)



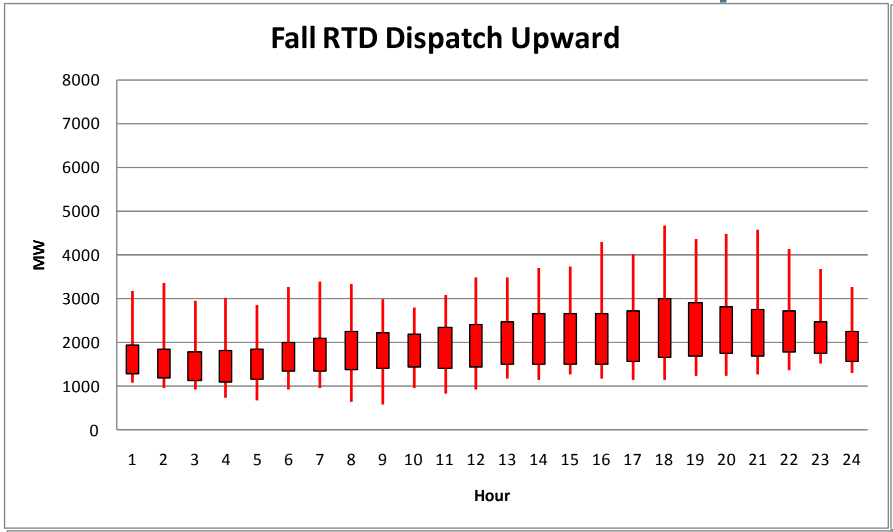
Decomposition of the operational requirements (5)

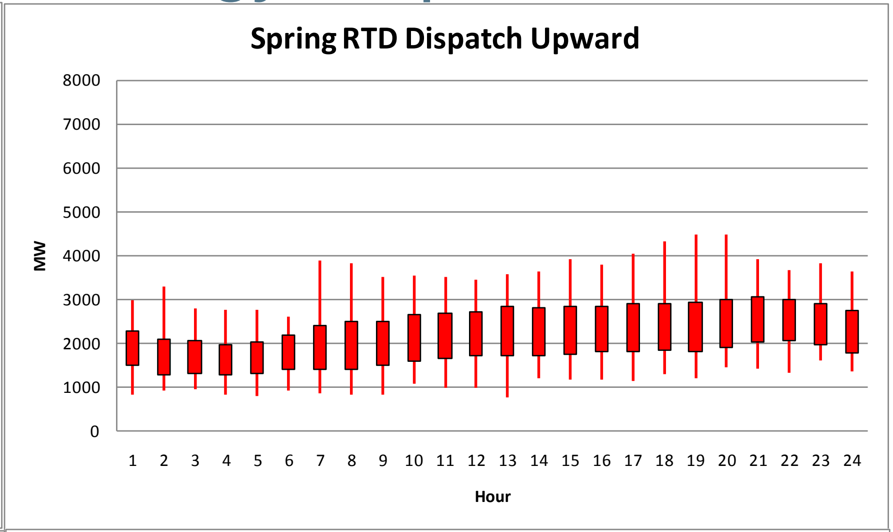


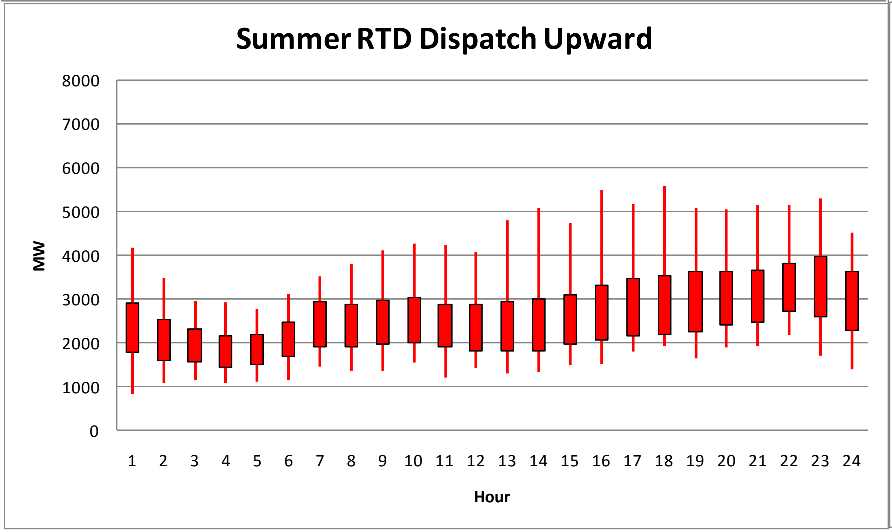
Decomposition of the operational requirements (6)

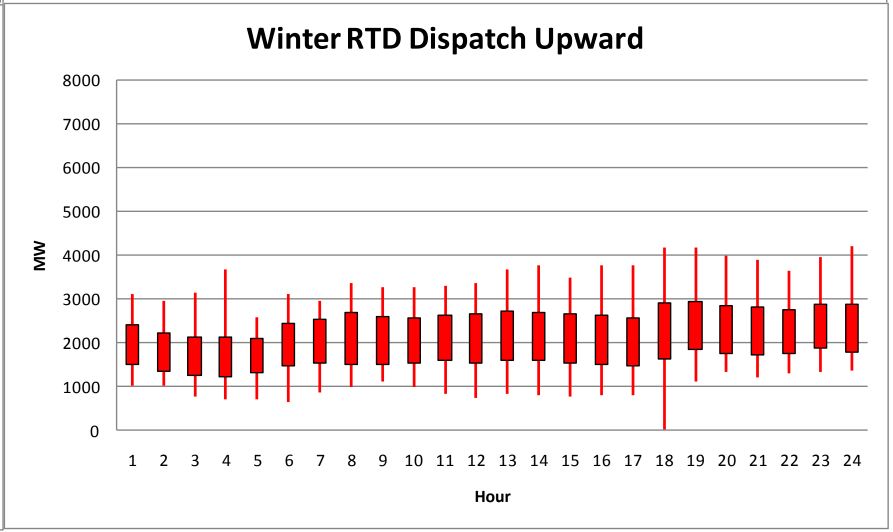


Actual Real-Time Upward Energy Dispatch:

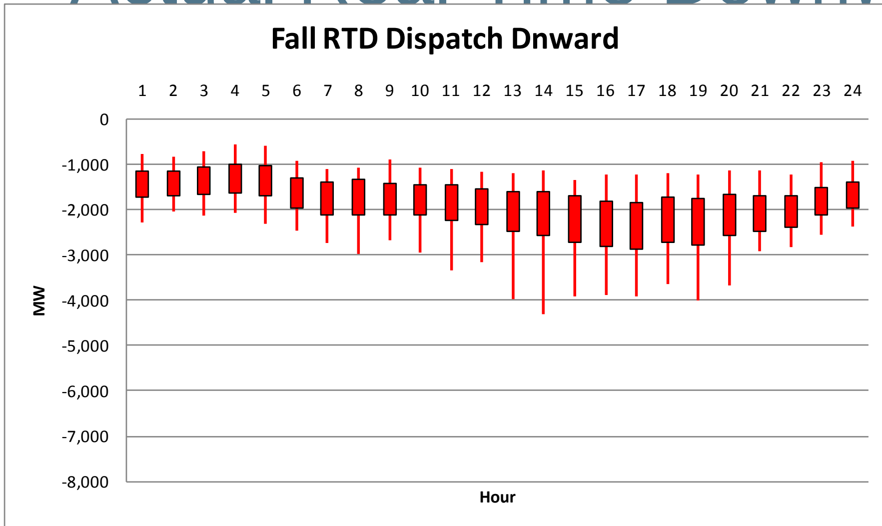


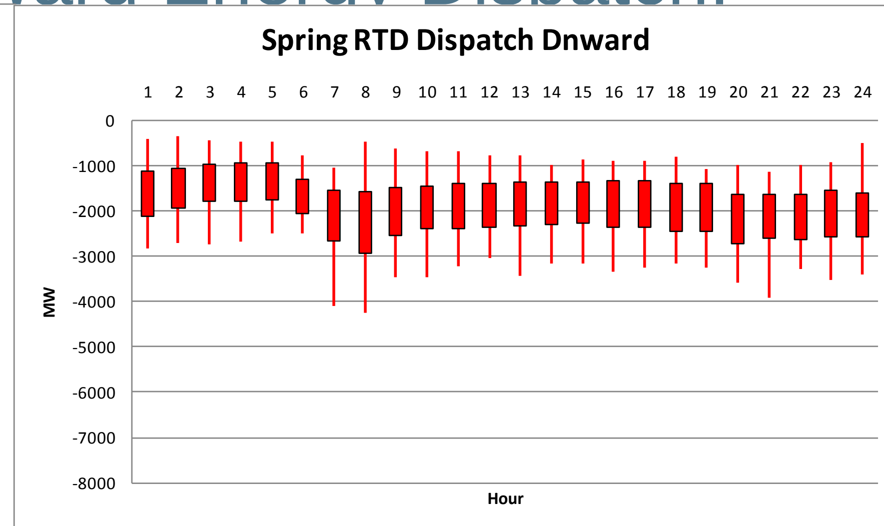


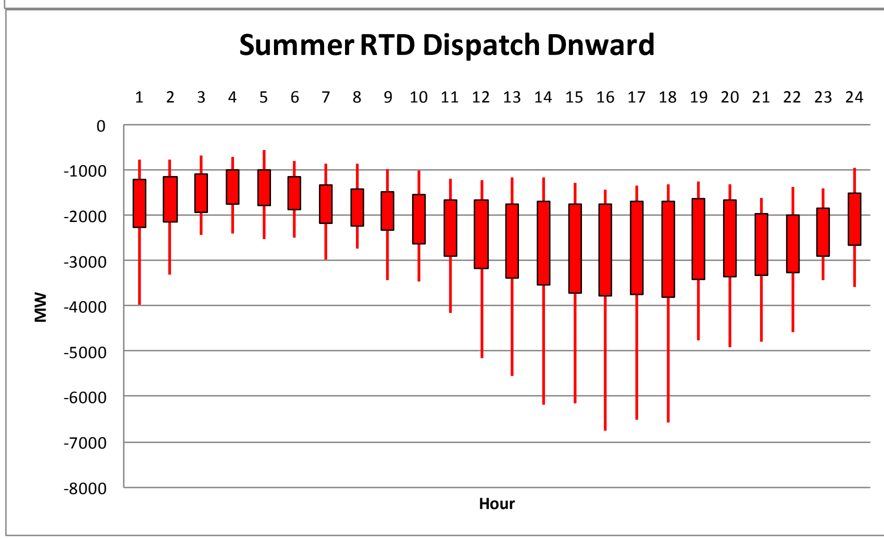


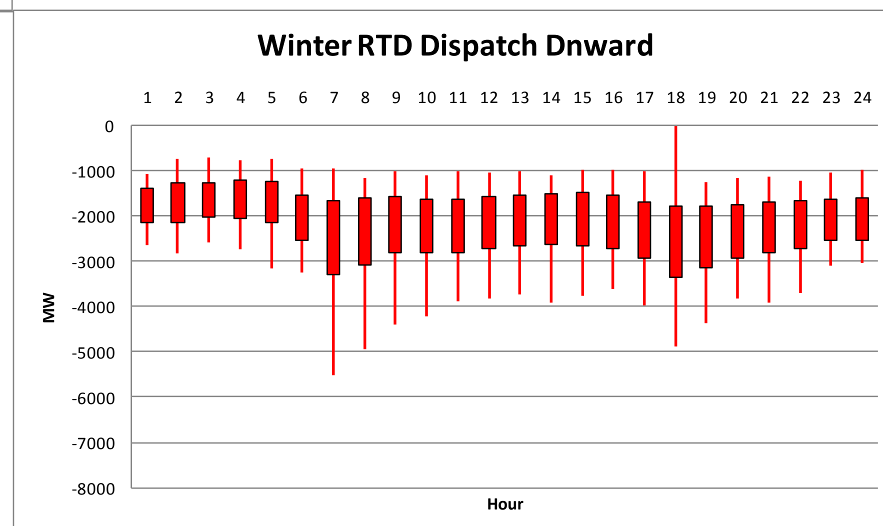


Actual Real-Time Downward Energy Dispatch:

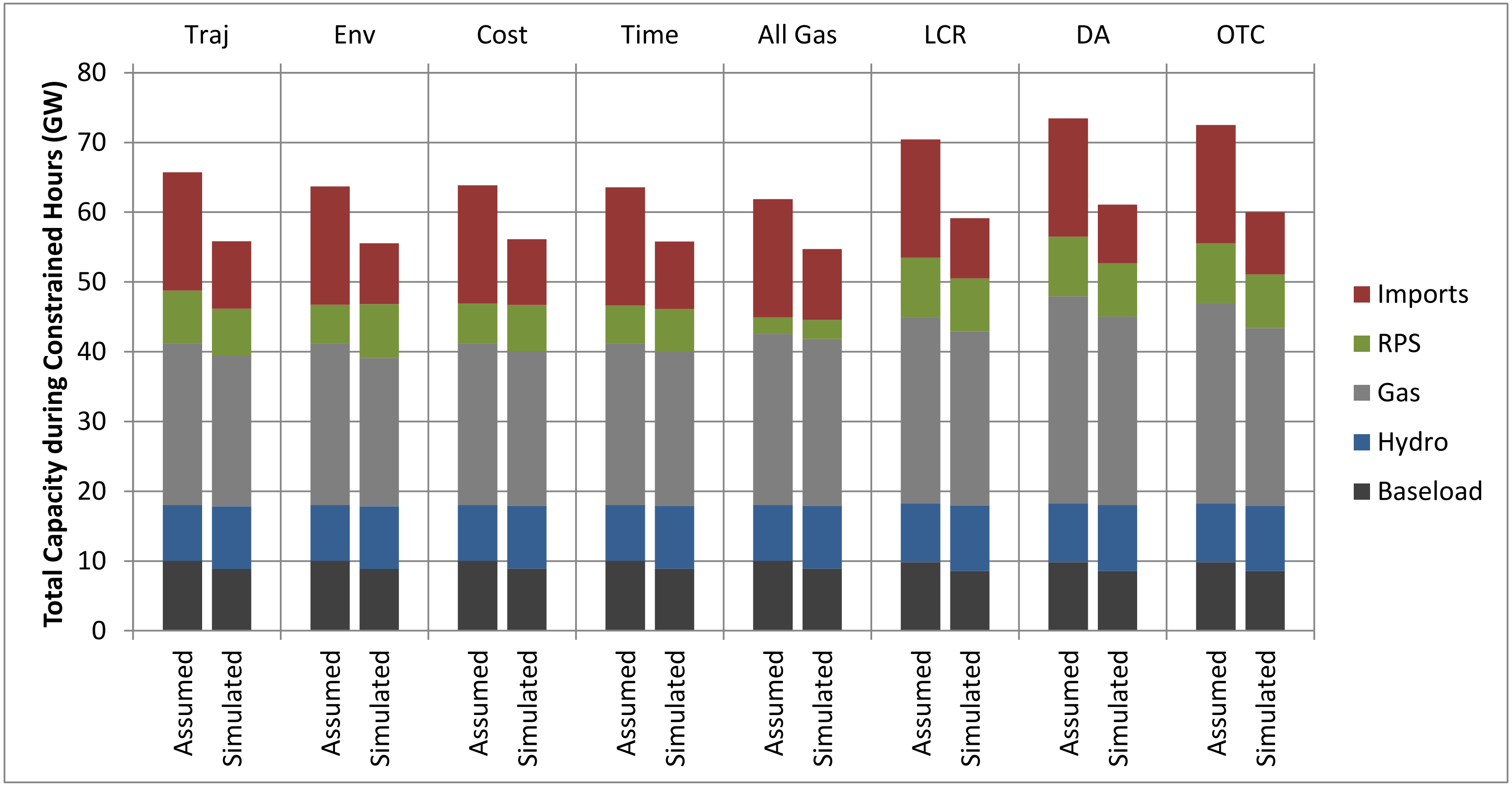








PRM Resources: Assumptions vs. Performance



Assumed: deemed (or assumed) NQC value of resource

Simulated: average resource performance during 50 constrained hours of PLEXOS simulation

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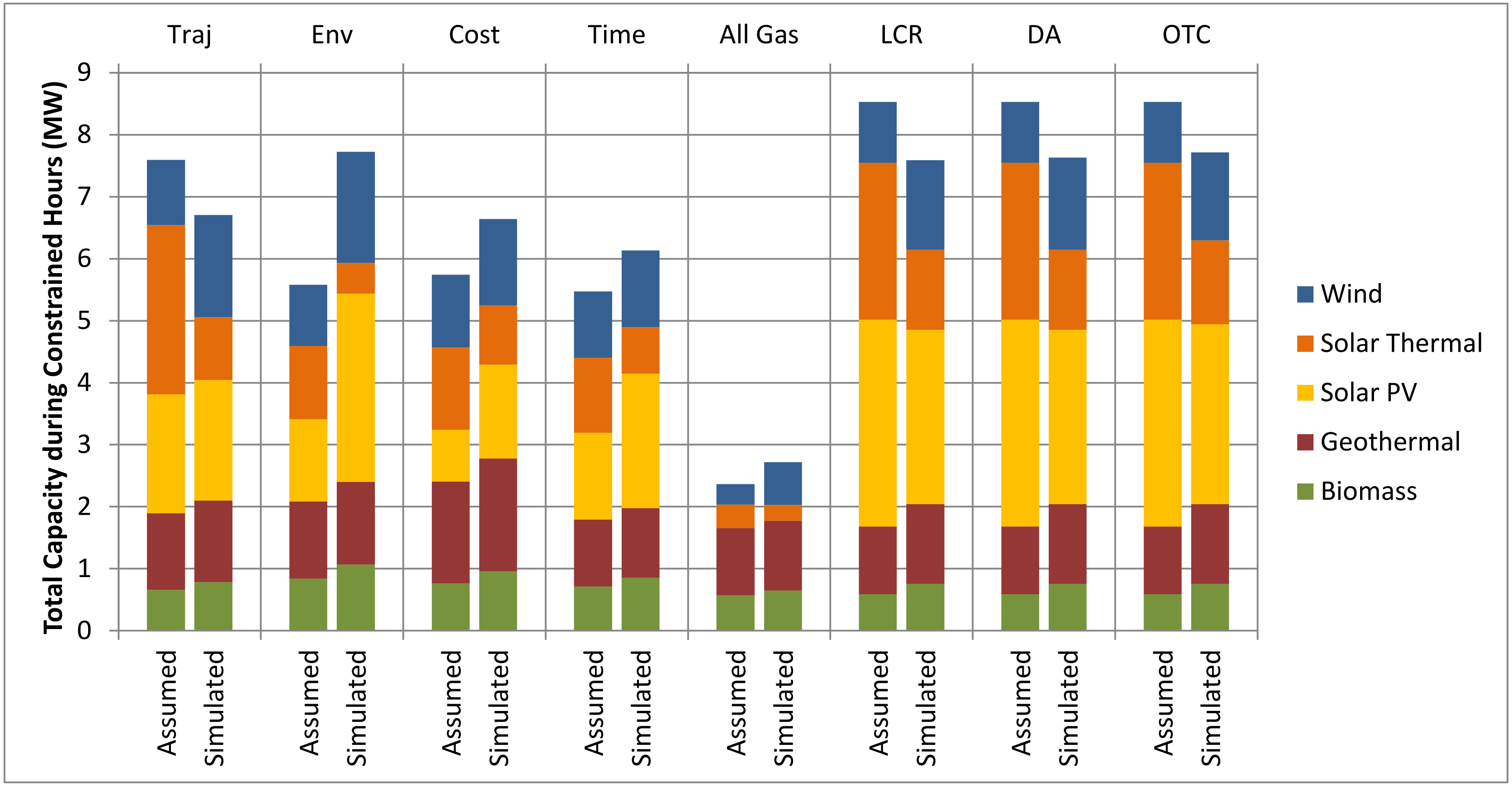
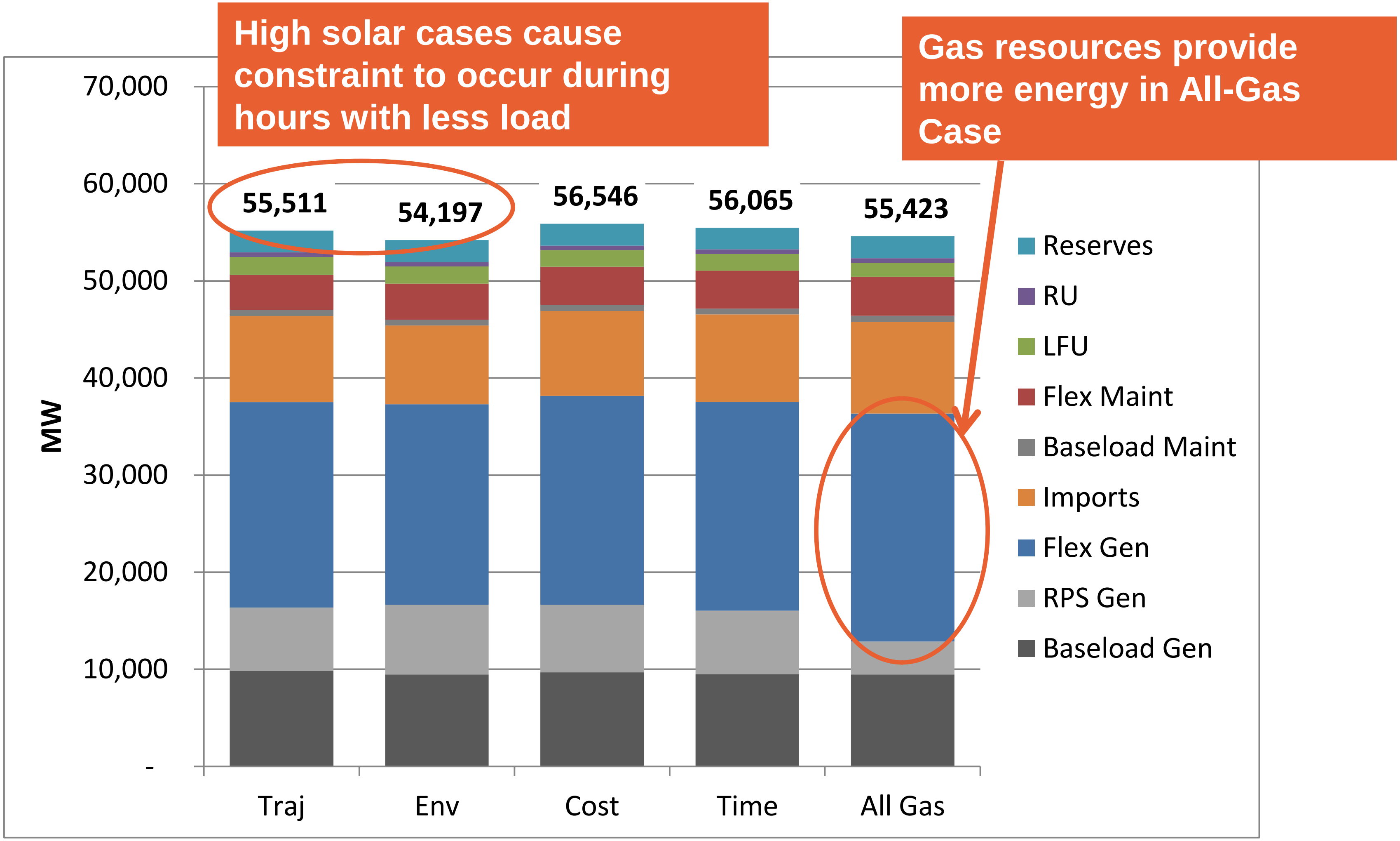
RPS Resources: Assumptions vs. Performance



Assumed: deemed (or assumed) NQC value of resource

Simulated: average resource performance during 50 constrained hours of PLEXOS simulation

CAISO Resources Used During Top 50 Constrained



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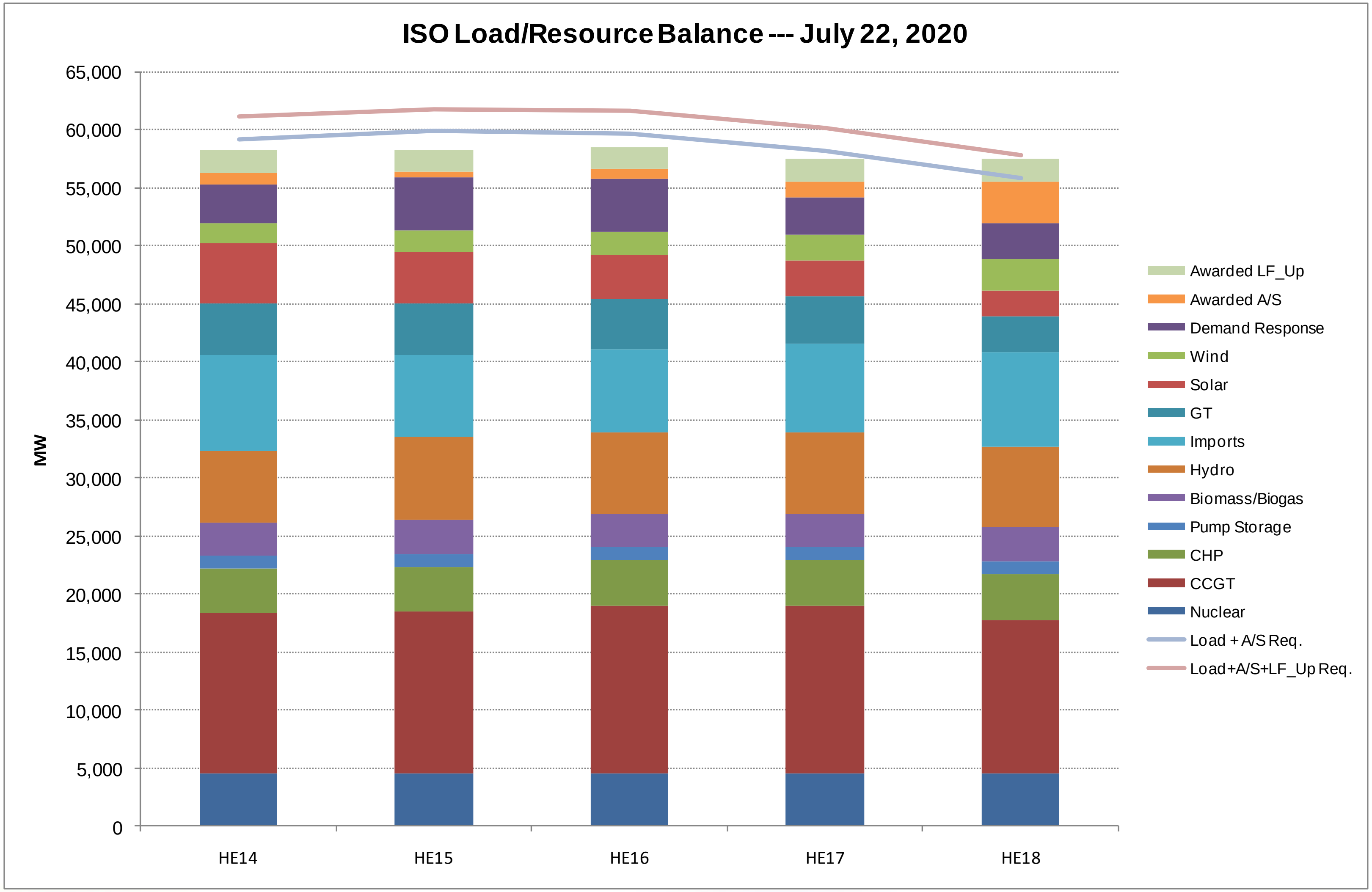
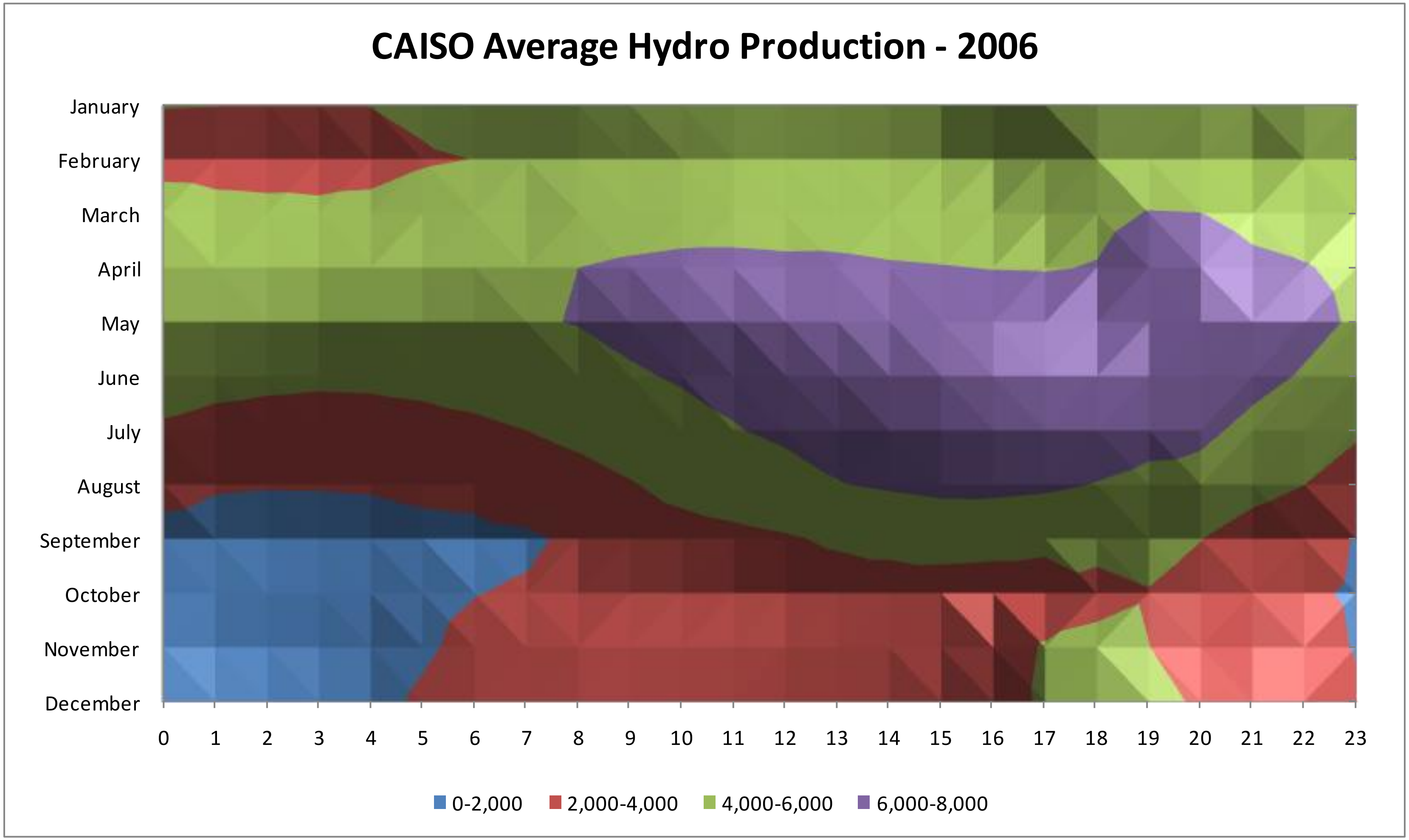
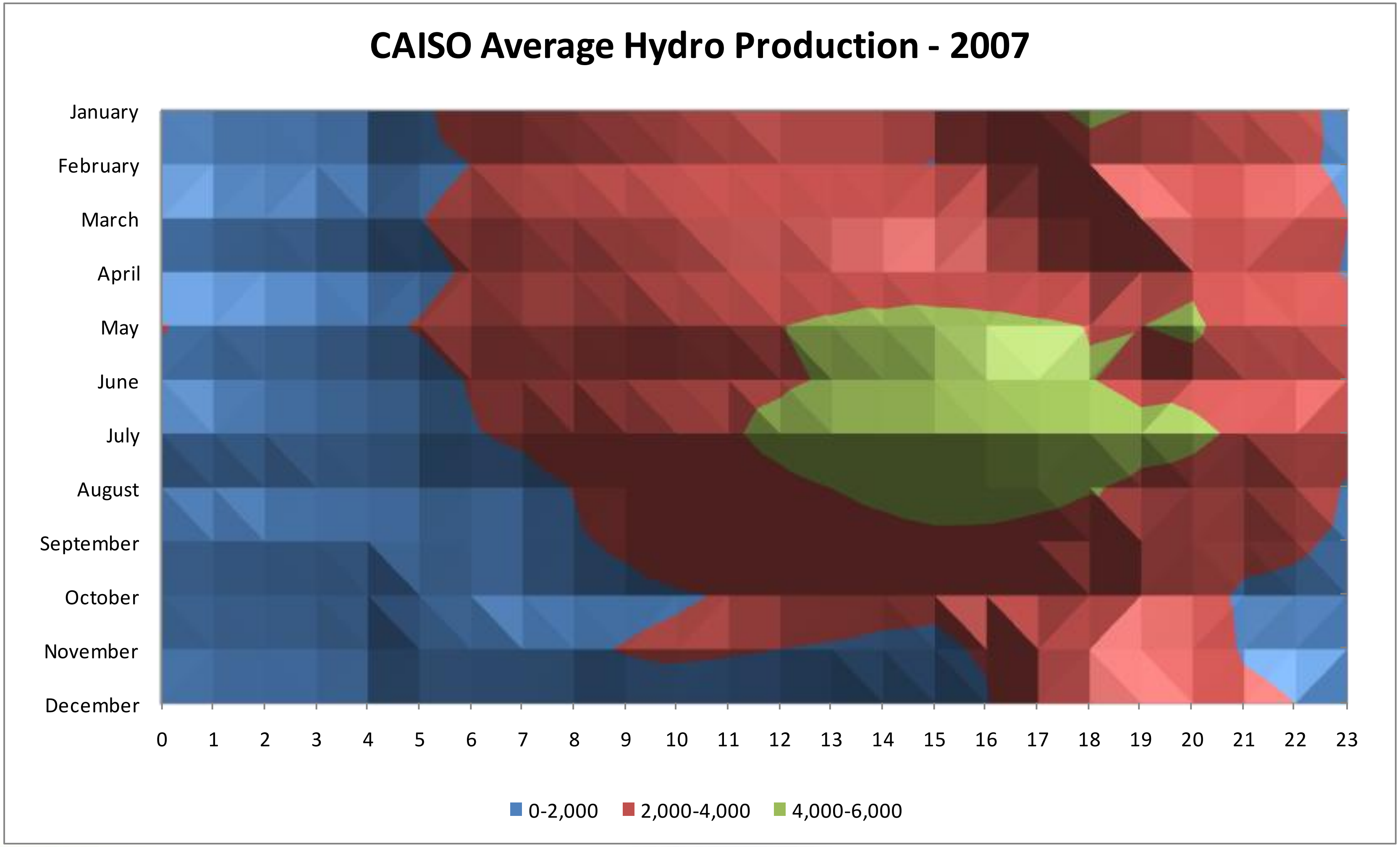
Loads/resources balance for July 22, 2020 High Load Scenario



Hydro patterns – 2006 High-Hydro Year



Hydro patterns – 2007 Low Hydro Year



Summary of previous requested work

- Incorporate results of LCR/OTC study work expected to complete in December 2011
- Identify timing and needs in intervening year analysis
- Consider resources that been approved since the scenarios were developed
- Perform probabilistic analysis to study risk and range of operational needs
  - Loss of Load Probability (LOLP)
- Perform additional analysis of planning reserve margin
  - Consider the “All Gas” case

Summary of previous requested work

- Perform operational requirements (regulation / load following) sensitivities
  - Assess impacts of different forecast errors
  - Decompose impacts of load, solar (technologies) and wind on requirements
  - Affects of controlled intertie ramp and quantity of import assumptions
  - Analyzes results to identify ramping speed and duration
  - Consider impact of market structure and timelines on forecast errors and requirements

- Perform production simulation sensitivities
  - Different load assumptions
  - Different maintenance profiles
  - Helms analysis that considers transmission constraints
  - Perform 5-minute simulation to validate load following shortages ~ energy shortage
  - Consider impact of market structure and timelines
  - Study different hydro patterns

- Perform phase 2 work that consider alternatives to meeting flexibility needs
  - Increase ramping flexibility of existing fleet sensitivity
  - Storage alternatives (may be able to leverage EPRI study work)
  - More flexible renewable technologies (may be able to leverage NREL study work))
  - Demand Response

Renewable integration related studies in progress at

1. 33% Renewable Integration studies
   - Scope next step of analysis to begin – October meeting
   - Incorporate LCR/OTC in studies – January 2012- March 2012
2. Annual resource adequacy evaluation
   - 2011 resource adequacy assessment – November 2011
3. Frequency/Inertia Study
   - Evaluate frequency response high renewable / low inertia
   - Complete, Report is being finalized by GE
4. Distributed Energy Resources
   - Evaluate the visibility / controllability cost and benefits
   - Scheduled completion: December 31, 2011

FRAMEWORK FOR PROBABILISTIC ANALYSIS

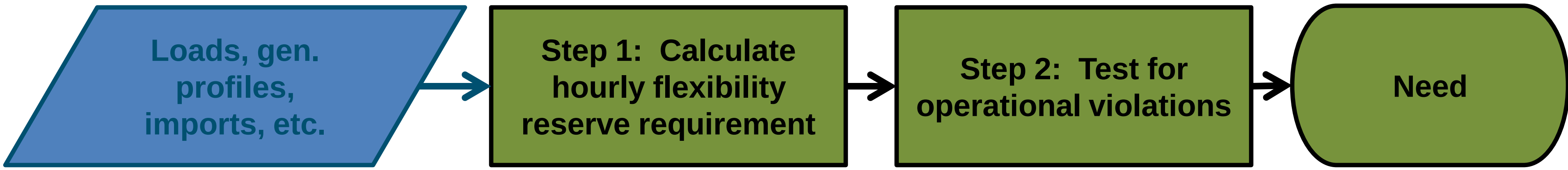
Shucheng Liu

A stochastic model is developed to assess the probability of upward ramping capacity shortage.

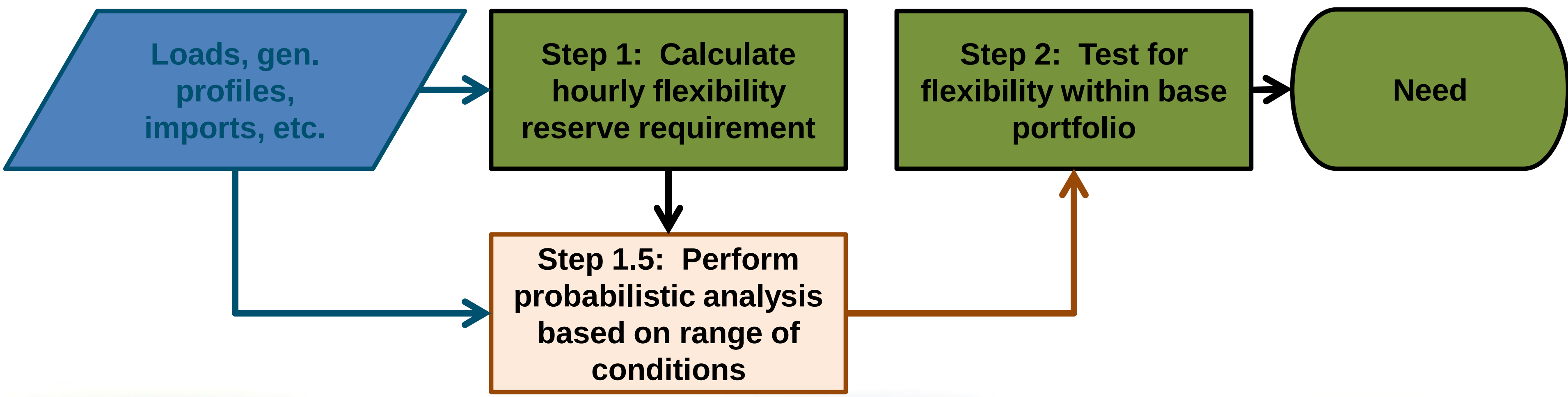
- A deterministic production simulation case adopts only one of the many possible combinations of input assumptions
- A stochastic model can evaluate various input combinations and determine the probability of ramping capacity shortage
- The stochastic model complements the deterministic production simulation

E3 Proposed Approach

Current Methodology



Potential Incorporation of Probabilistic Analysis



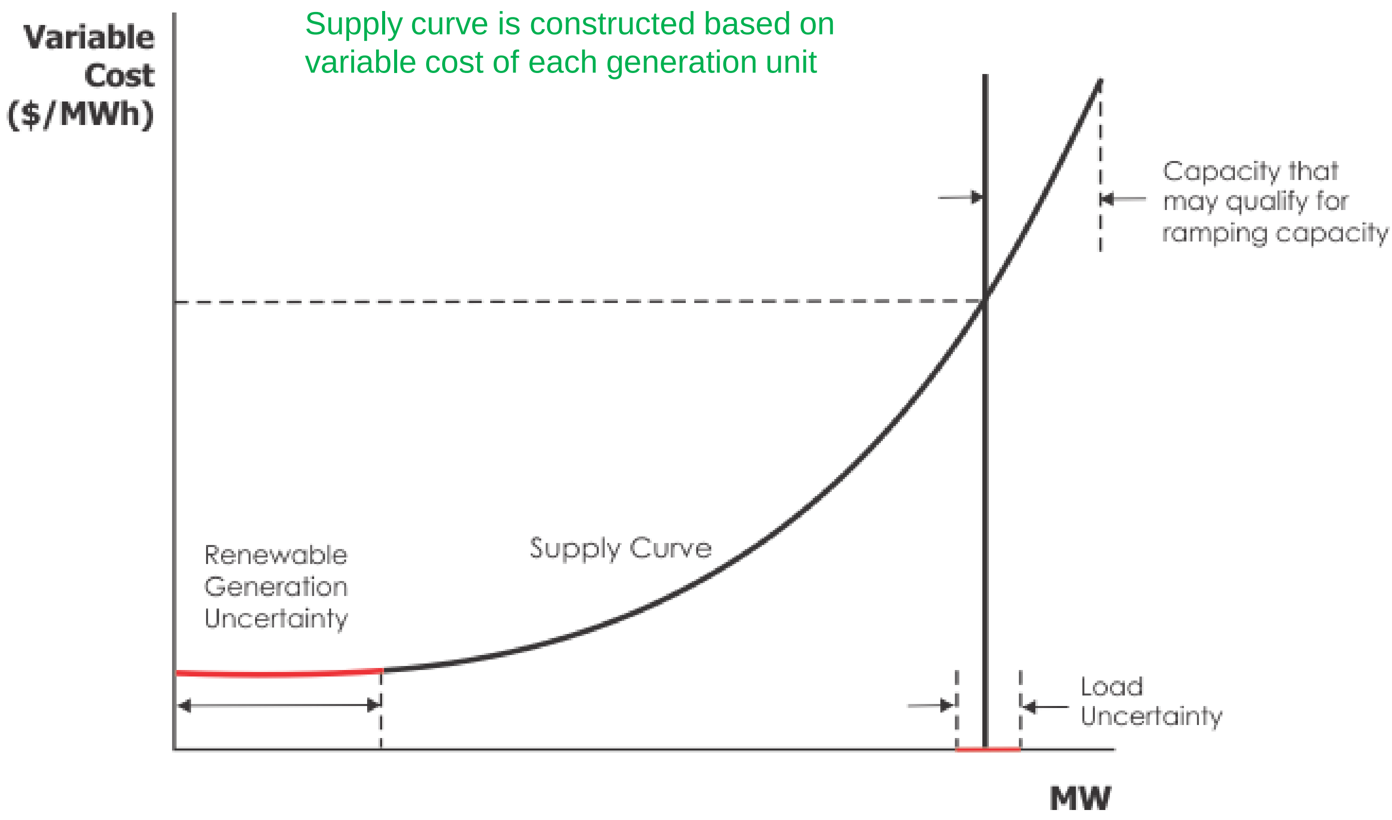
The stochastic model considers uncertainties in some of the key model inputs, including:

- California load forecast
- Requirements for regulation-up service and load following-up
- Generation by wind, solar, and hydro resources
- California import capability
- Availability of each generation unit

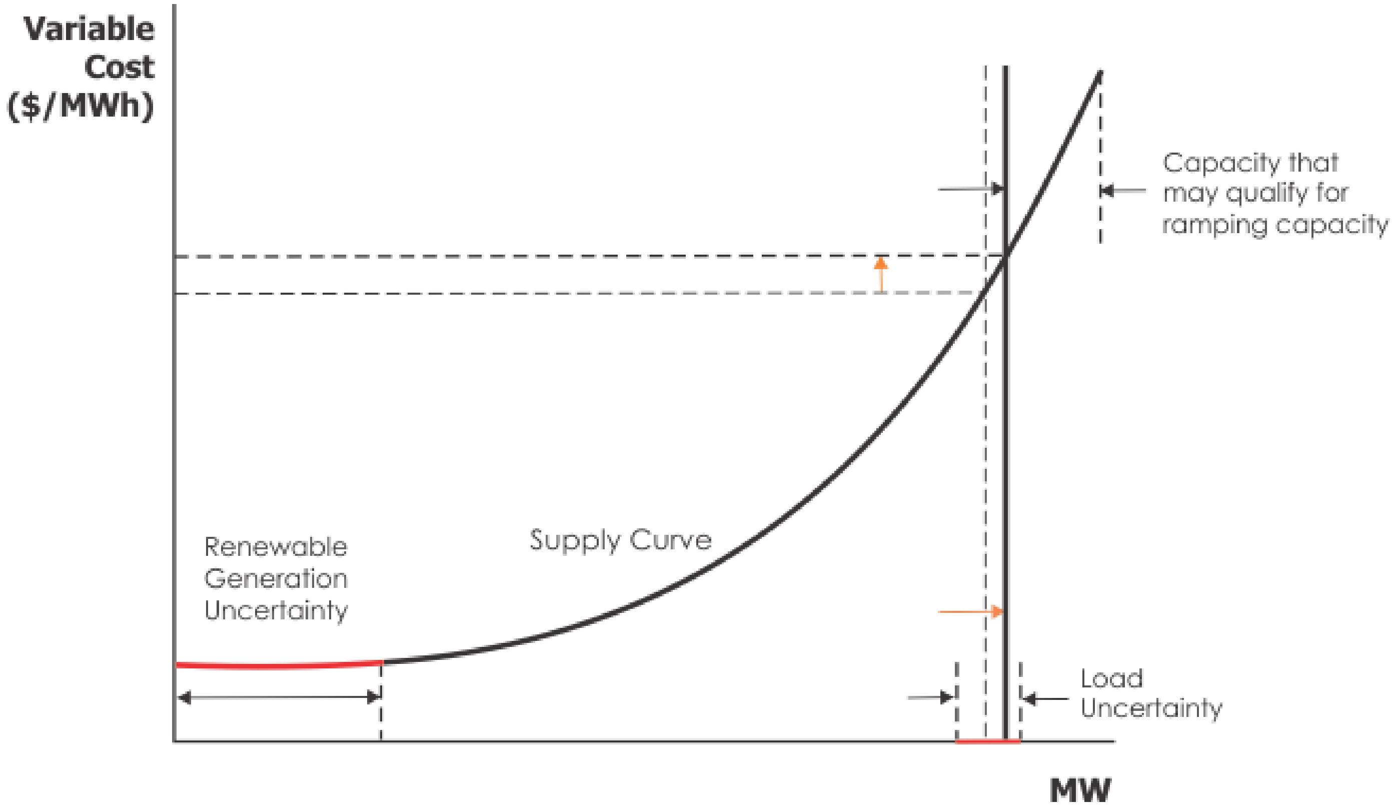
It is not a chronologic unit commitment simulation model.

- No unit commitment decision
- No chronologic constraint (such as min run time and min down time, etc.)
- Sequential capacity usage as initial design
  - Dispatching capacity economically to meet load first
  - Qualifying remaining capacity for ramping capacity to meet upward ancillary service and load following requirements
- Co-optimization between energy and ramping capacity implemented

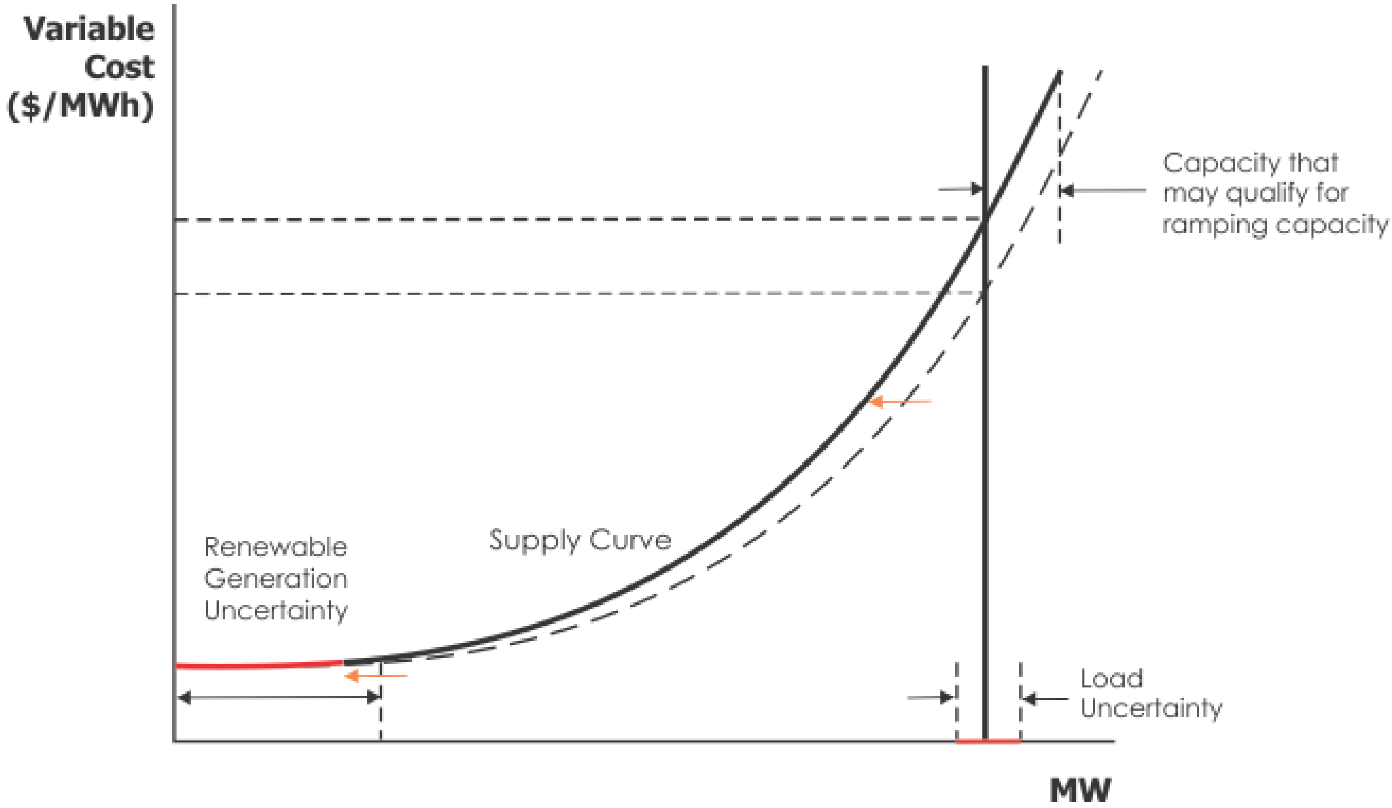
Available ramping capacity depends on the balance of supply and load.



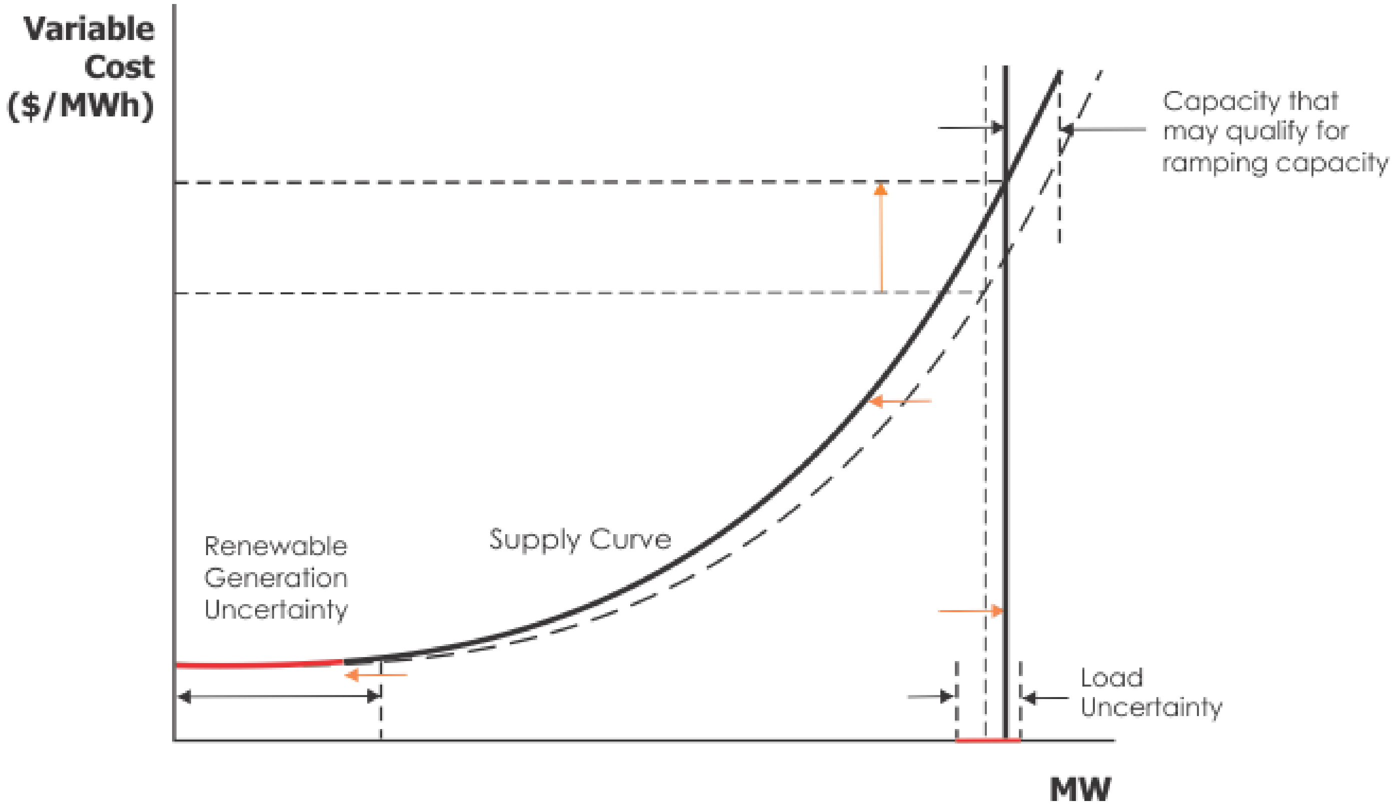
Variation in load due to uncertainty affects availability of ramping capacity.



Variation in supply due to uncertainty in renewable generation also affects availability of ramping capacity.



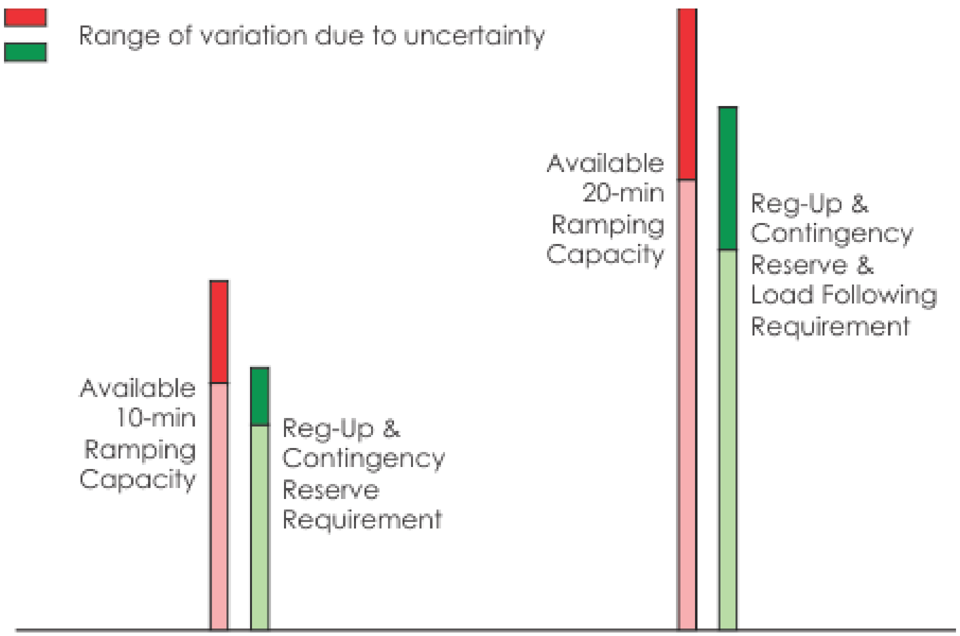
Variations in both load and supply may occur at the same time.



Available ramping capacity of each generation unit is qualified based on the following factors:

- Maximum and minimum capacity
- Dispatch level
- Ramp rate
- Ramp time (10 or 20 minutes)
- Commitment status (for demand response resources that can provide off-line non-spinning only)
- Unit availability (due to forced and maintenance outages)

Available ramping capacity is used to meet ancillary service and load following requirements.



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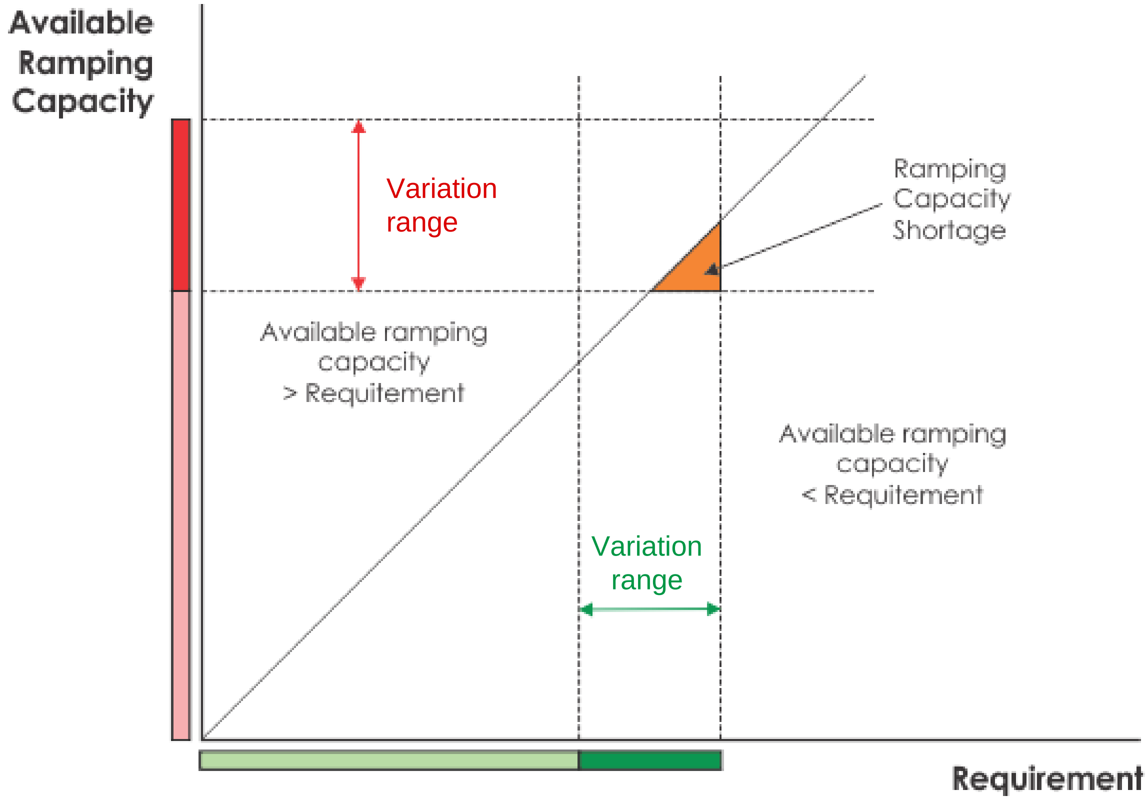
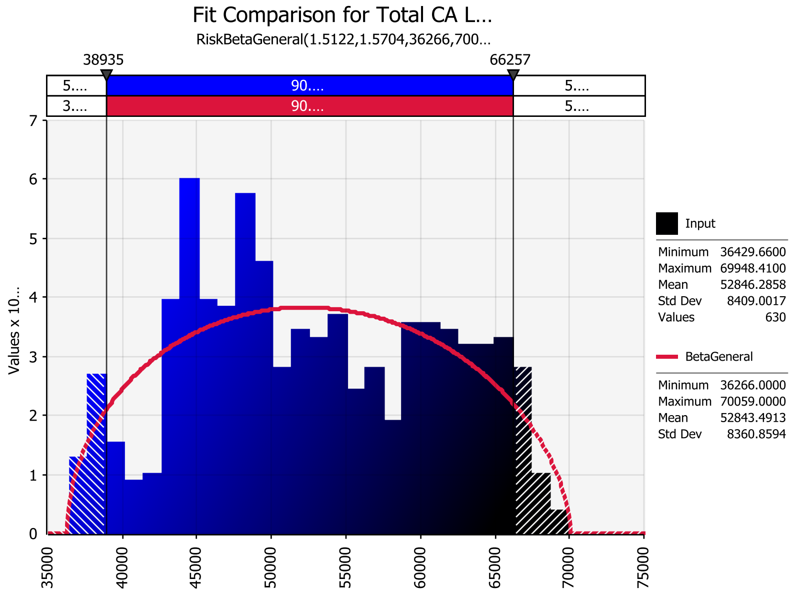
Shortage may occur due to the variations in available ramping capacity and requirement.

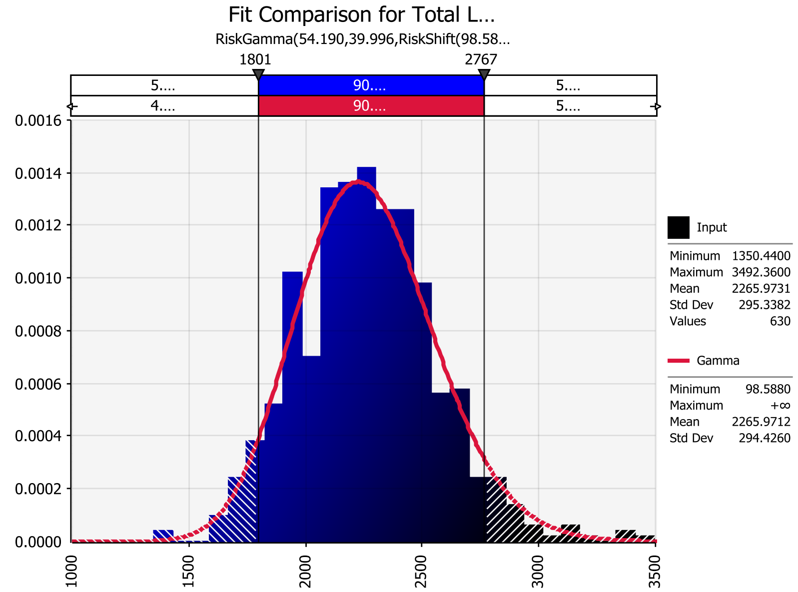


The model is developed based on input and output data of the Plexos production simulation model.

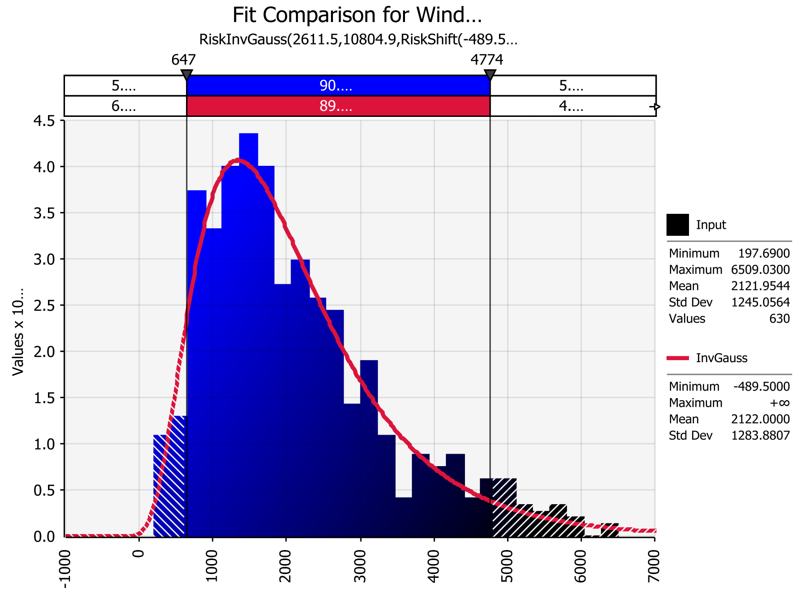
- From input data
  - Hourly California load forecast
  - Hourly regulation and load following-up requirement
  - Hourly wind, solar, and hydro generation
  - California import limit and hourly import and export
  - Generator characteristics (capacity, ramp rate, forced and maintenance outage rates, etc.)
- From output data
  - Variable generation cost of each generation unit ($/MWh)

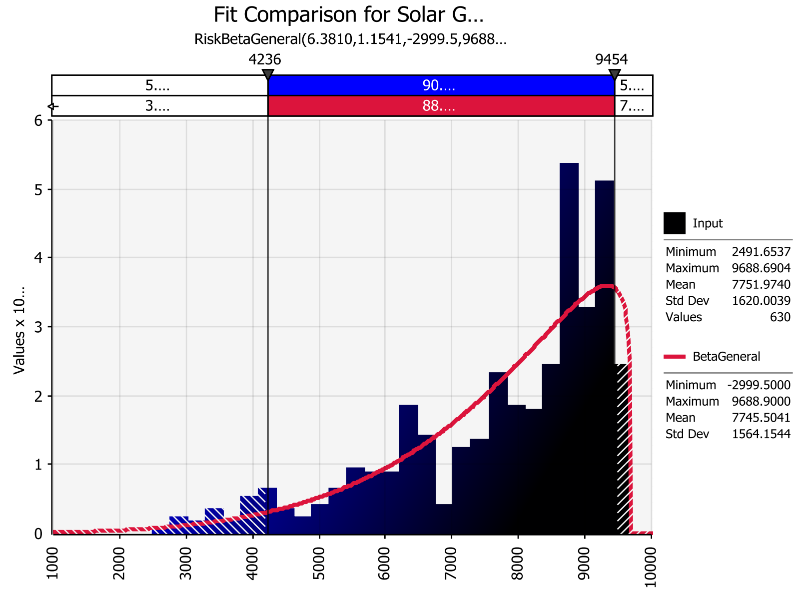
These are examples of the input probability distribution functions fitted based on hourly sample data.





Input probability distribution functions examples (cont.)





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Correlations among the stochastic variables are enforced.

<table>
<tr><th></th><th>Load</th><th>Import</th><th>Wind</th><th>Solar</th><th>Hydro</th><th>RegU</th><th>LFU</th></tr>
<tr><td>Load</td><td colspan="7" rowspan="7">ρ</td></tr>
<tr><td>Import</td></tr>
<tr><td>Wind</td></tr>
<tr><td>Solar</td></tr>
<tr><td>Hydro</td></tr>
<tr><td>RegU</td></tr>
<tr><td>LFU</td></tr>
</table>

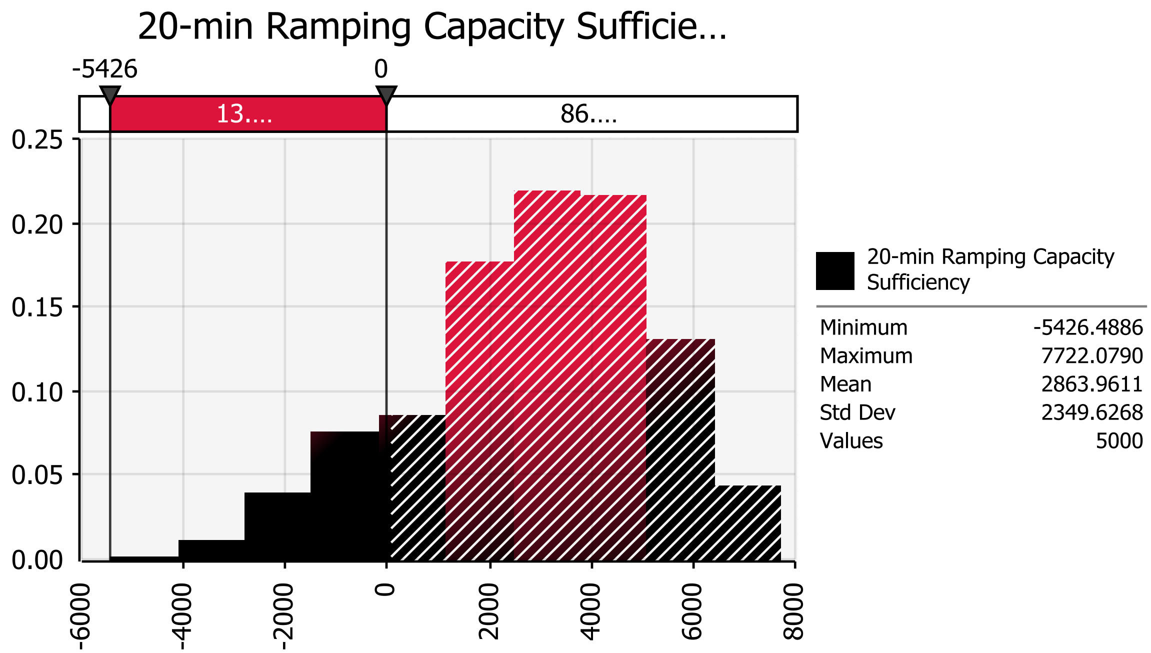
Generation unit forced and maintenance outages are stochastically determined.

- Forced and maintenance outages are determined independently for each generation unit
- Each of the outages is determined based on the unit's outage rate and a draw using a uniform distribution function
- The unit is unavailable when one or both outages occur

Monte Carlo simulation of the model produces probabilistic results.

- Monte Carlo simulation is conducted using this stochastic model
- The simulation results are presented in a probability distribution format

This is an example of the Monte Carlo simulation result - probability distribution of 20-min ramping capacity sufficiency.



The model can also be used in other ways for different purposes.

- Constructing the supply curve based on different criteria (without co-optimization), such as
  - by ramp rates from high to low – least ramping capacity is left to meet upward AS and LF requirements
  - by ramp rates from low to high – most ramping capacity is left to meet upward AS and LF requirements
- Evaluating the effects of adding additional resources into the system

Commercial software is used to run Monte Carlo simulations of the model

- Model is developed in Excel
- Commercial software is used to run model simulations with co-optimization

  Frontline Risk Solver Platform for Excel

  http://solver.com/platform/risk-solver-platform.htm

Question?