2017 ISO New England System Operational Analysis and Renewable Energy Integration Study (SOARES)

Study Methodology

Prof. Amro M. Farid

Thayer School of Engineering at Dartmouth

PAC Meeting
Westborough, MA
August 3, 2017

LIINES LABORATORY FOR INTELLIGENT INTEGRATED NETWORKS OF ENGINEERING SYSTEMS
EMPOWERING YOUR NETWORK

http://engineering.dartmouth.edu/liines

Presentation Outline

Goal: To describe the methodology by which we will conduct the SOARES project (2017 ISO New England System Operational Analysis and Renewable Energy Integration Study)

- **Need for Holistic Electric Power Enterprise Control Assessment**
  - *As the electric generation mix in New England evolves in the coming years, the impacts on technical performance must be assessed within holistic frameworks that include exogeneous as well as endogeneous characteristics.*

- Electric Power Enterprise Control Simulation for ISO New England
  - *The Electric Power Enterprise Control Simulator (EPECS) can be used to assess how the ISO New England power system would respond to various electric generation mix scenarios.*

- Methodology for Integrating EPECS into the SOARES Project
  - *With the electric power enterprise control simulation in place, ISO New England can objectively assess power grid imbalances and the need for operating reserves within a single integrated environment.*

Fundamental Changes in Grid Dynamics

Past:

Generation/Supply	Load/Demand
Thermal Units: (Few, Well-Controlled, Dispatchable Resources)	Conventional Loads: (Fairly Slow Moving, Highly Predictable, Always Served)

Future:

	Generation/Supply	Load/Demand
Well-Controlled & Dispatchable	Thermal Units: (Potential Erosion of Capacity Factor) ↓	
Stochastic/ Forecasted	Solar & Wind Generation: (Variability can cause unmanaged grid imbalances) ↑	Conventional Loads: (Continuing source of variability & uncertainty)

∴ **Renewable energy integration causes fundamental changes in grid dynamics**

∴ **Erodes the power grid's overall dispatchability**

Guiding Assessment Structure for Power Grids

In the face of fundamental change in the resource mix, a structured holistic view for assessing power system evolution is needed with the following considerations:

- **Full Electricity Supply Chain**: This includes generation, transmission, and demand
- **Dispatchability of Energy Resources**: This includes dispatchable & variable resources
- **All relevant layers of control**: This includes commitment decisions, balancing dispatch, & regulation
- **All relevant technical objectives**: The SOARES project includes balancing & interface congestion performance.

∴ **Integrates well established power system paradigms**

Renewable Energy Integration Study Review

Renewable energy integration studies provide the most holistic assessment techniques for studying the evolution of the electric power system.

∴ The Dartmouth LIINES have conducted a comprehensive review of renewable energy integration studies [3].

Renewable Energy Integration Study Review

Historical renewable energy integration studies provide the most holistic assessment techniques for smart grid development, but have their limitations….

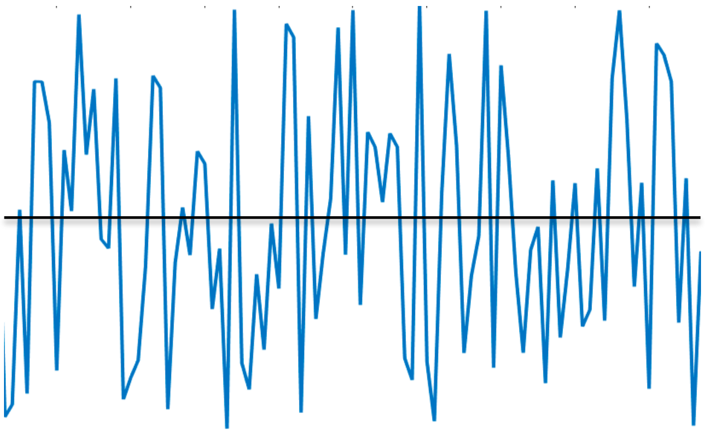
- Operating costs are limited to energy production costs … but it is the ancillary services that will drive grid performance.
- The assessment of voltage and line congestion is not always studied …but these properties can be key performance criteria with spatially-distributed variable energy resources.
- The assessment of operating reserves requirements is generally determined statistically … but simulation is required to test existing assumptions & statistics.

∴ There is a need to develop beyond the methodologies used in past renewable energy studies.

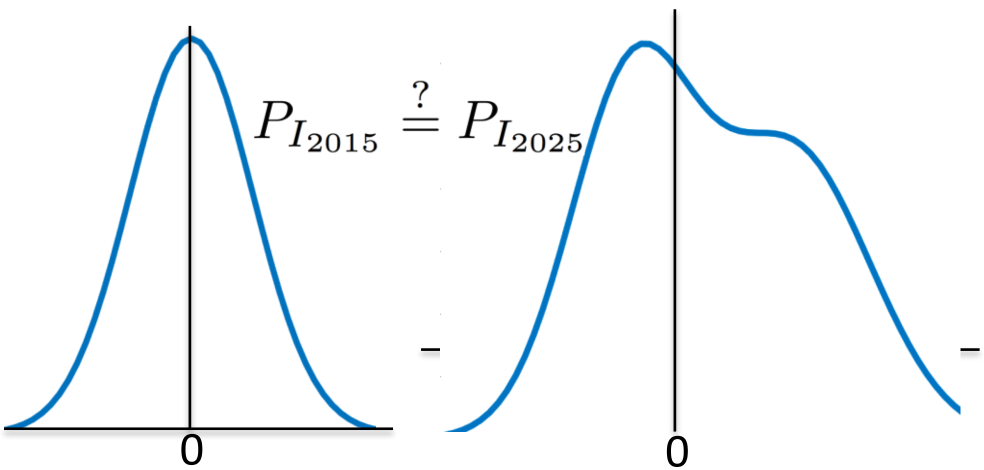
Revisiting Inherent Statistical Assumptions

Some Renewable Energy Integration Studies make the following assumptions in their reserve requirement calculations [4]:

- **Assumption 1:** *Invariant Probability Density Function of Imbalances*: will have the same shape from year to year (*even as the resource and load portfolio changes*)



Imbalances in 2015



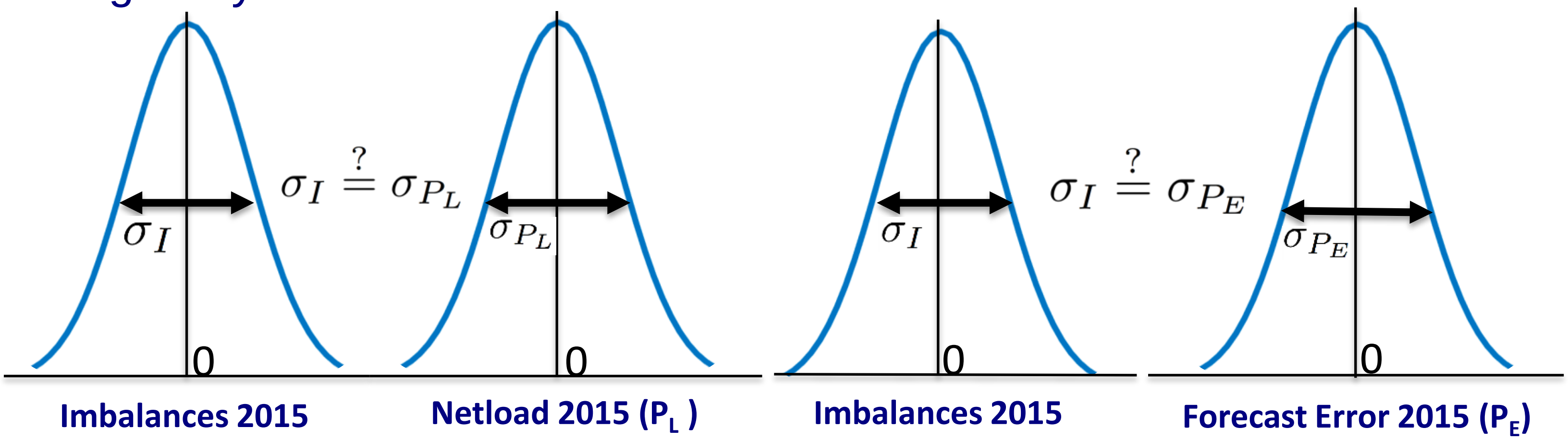
Imbalances in 2015 Imbalances in 2025

∴ **Because there is no research to support this assumption, we do not make it.**

Revisiting Inherent Statistical Assumptions

Some Renewable Energy Integration Studies make the following assumptions in their reserve requirement calculations [4]:

- **Assumption 2:** *Equivalence of Standard Deviations*: The standard deviation of imbalances is equivalent to either the net load variability or its forecast error in a given year.

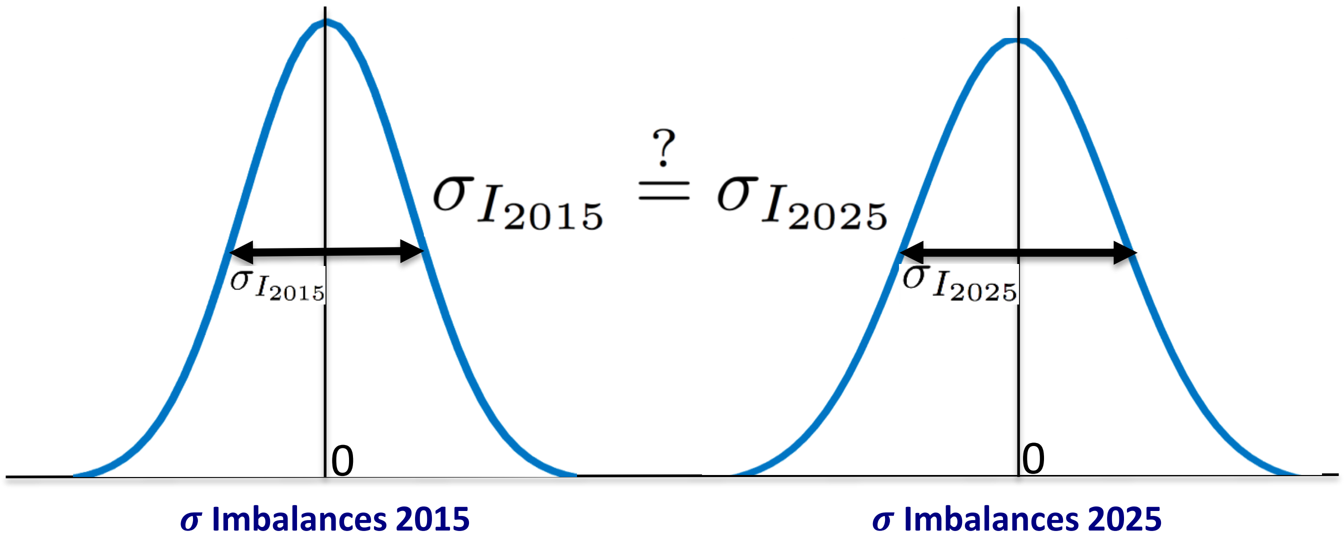


∴ **Because there is no research to support this assumption, we do not make it.**

Revisiting Inherent Statistical Assumptions

Some Renewable Energy Integration Studies make the following assumptions in their reserve requirement calculations [4]:

- **Assumption 3:** *Invariance of the Standard Deviation*: The standard deviation of the imbalances will have the same magnitude from year to year.

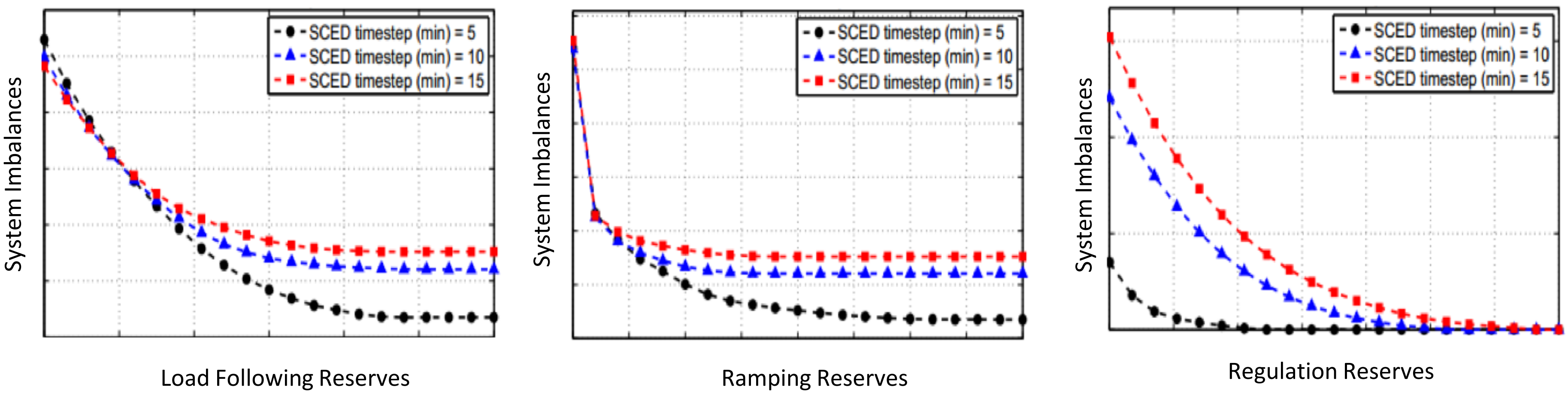


∴ Because there is no research to support this assumption, we do not make it.

Revisiting Inherent Statistical Assumptions

Some Renewable Energy Integration Studies make the following assumptions in their reserve requirement calculations [4]:

- **Assumption 4:** *Non-dependence on Power System Operator Decisions & Control*: The standard deviation of imbalances does not depend on the power system operator's control and operations decisions.



∴ Because there is no research to support this assumption, we do not make it.

∴ Furthermore, the assumption may contradict the logic of FERC Order 764 which reduces the time step between SCED decisions.

Advancing Renewable Energy Integration Studies

∴ There exists a need for new methodologies to conduct renewable energy integration studies without making these assumptions.

∴ The Dartmouth-LIINES has developed the Electric Power Enterprise Control System (EPECS) simulator to address this need.

Presentation Outline

Goal: To describe the methodology by which we will conduct the SOARES project (2017 ISO New England System Operational Analysis and Renewable Energy Integration Study)

- Need for Holistic Electric Power Enterprise Control Assessment
  - *As the electric generation mix in New England evolves in the coming years, the impacts on technical performance must be assessed within holistic frameworks that include exogeneous as well as endogeneous characteristics.*
- **Electric Power Enterprise Control Simulation for ISO New England**
  - *The Electric Power Enterprise Control Simulator (EPECS) can be used to assess how the ISO New England power system would respond to various electric generation mix scenarios.*
- Methodology for Integrating EPECS into the SOARES Project
  - *With the electric power enterprise control simulation in place, ISO New England can objectively assess power grid imbalances and the need for operating reserves within a single integrated environment.*

Electric Power Enterprise Control System (EPECS) Simulator for Holistic Techno-Economic Assessment

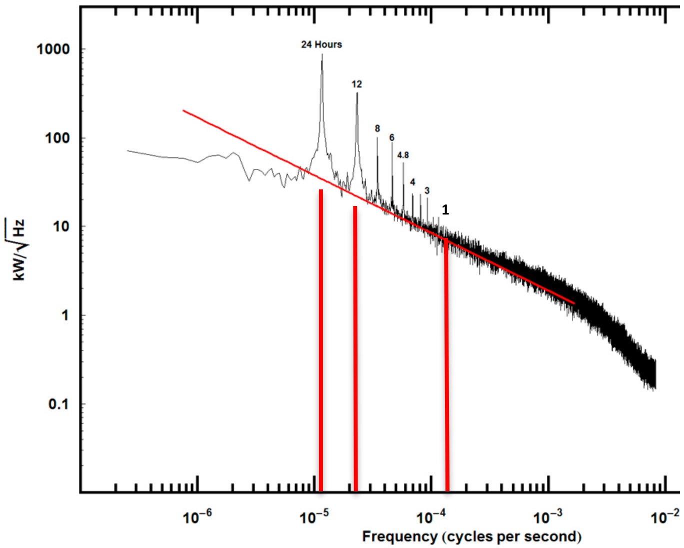
- The conduct of renewable energy integration studies by EPECS simulation has been published multiple times.
- These publications have received extensive processes of scientific peer-review.
- All publications are freely available to the public on the LIINES website.

∴ The EPECS simulation has been reviewed and accepted multiple times by the scientific community.

Variability & Uncertainty in Solar Power Generation

- Solar PV integration is often studied in the time domain. (See figure on left for data from Nevada on a cloudy day) ... But this masks a key insight.
- Looking at Solar PV in terms of the spectrum of its frequencies shows that it introduces dynamics over many time scales (24 hr, 12 hr, 1 hr, etc…). (See figure on right.)

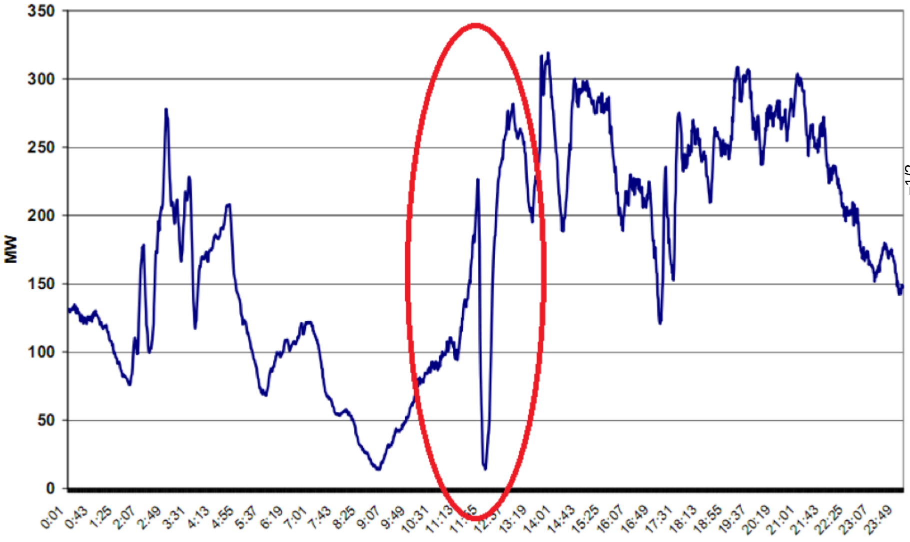
Source: NERC 2009

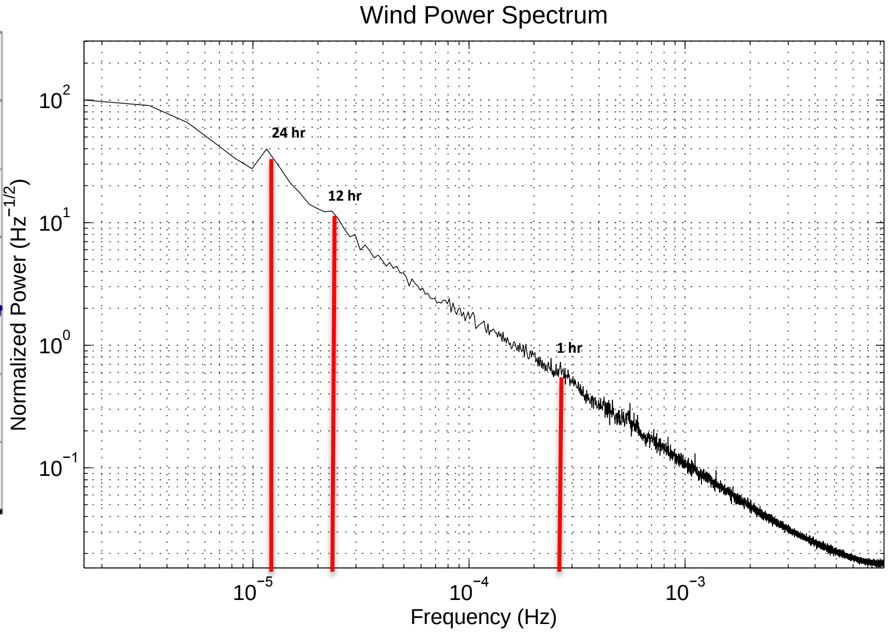


∴ **A multi-time scale approach is required for rigorous assessment**

Variability & Uncertainty in Wind Power Generation

- Wind integration is often studied in the time domain. (See figure on left from ERCOT) ... But this masks a key insight.
- Looking at wind generation in terms of the spectrum of its frequencies shows that it introduces dynamics over many time scales (24 hr, 12 hr, 1 hr) – without the peaks of daily behavior. (See figure on right.)





∴ A multi-time scale approach is required for rigorous assessment

Electric Power Enterprise Control Simulator (EPECS)

- The Electric Power Enterprise Control Simulator (EPECS) was developed to address the multi-time scale nature of renewable energy integration.
- It avoids making the assumptions described previously.
- It's central strategy is to mimic the the operations of a power system operator.
- Included simulation functionality: Day-Ahead Resource Scheduling, Real-Time Balancing, and Regulation Service.
- This gives deep insight into the need for different types of operating reserves.

∴ The EPECS Simulator is a reconfigurable, multi-layered, multi-time horizon, control, automation, & optimization system for holistic power system analysis

ISO-NE Electric Power Enterprise Control Simulator

- For the SOARES project, we tailor the EPECS simulator to the ISO-NE Power System Operations.
- It's central strategy is to mimic the the operations of ISO-NE.
- Included simulation functionality: Day-Ahead Resource Scheduling, Same-Day Resource Scheduling, Real-Time Balancing, and Regulation Service.
- This gives deep insight into the need for different types of operating reserves.

∴ We have now customized the EPECS simulator for the relevant parts of ISO New England's operating procedures including commitment and dispatching decisions.

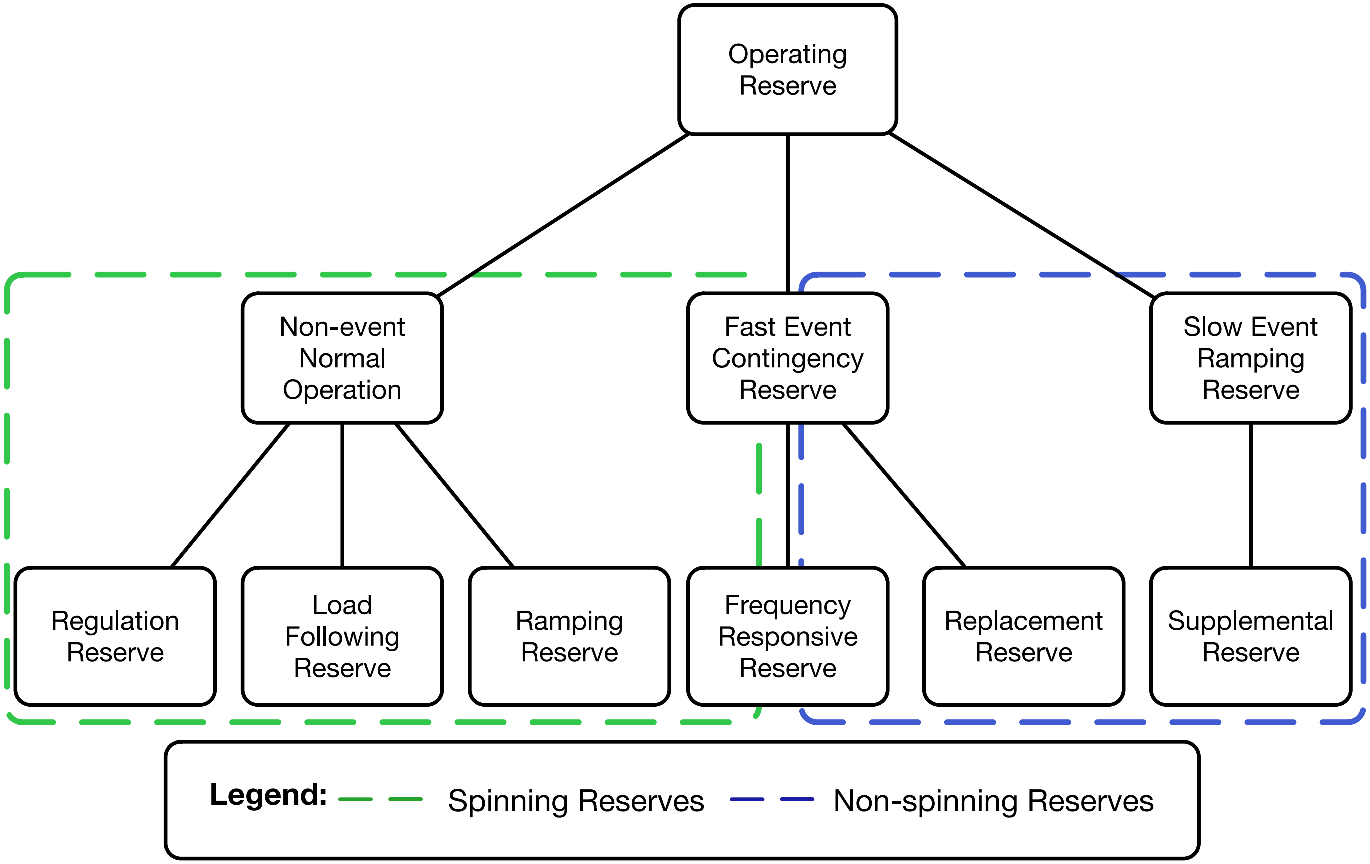
Reconciling Concepts on Operating Reserves

- Every region has a completely different concept of operating reserves.
- Leading researchers in renewable energy integration have recognized this lack of uniformity and developed their own taxonomy [10].
- We have also adopted this taxonomy in the EPECS simulator. We now:

1. Present this taxonomy of operating reserves
2. Contrast it to operating reserve quantities at ISO New England
3. Show how the two taxonomies of operating reserves will be reconciled

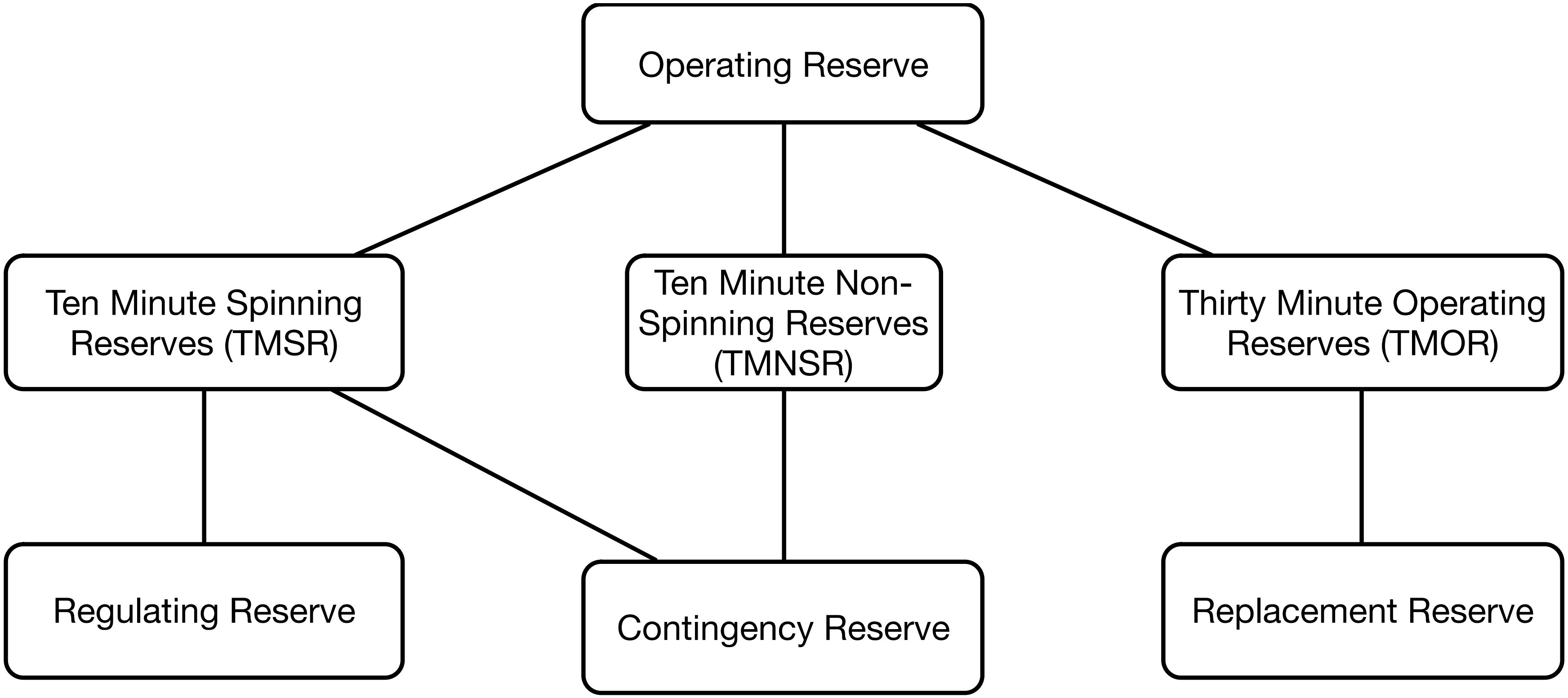
∴ Having a strong conceptual understanding of operating reserves is essential to achieving sound results.

Operating Reserves: The Literature View [9]



∴ This taxonomy delineates spinning and non-spinning reserves and their roles. There is a general consensus that variable energy integration is about having sufficient spinning reserves in normal operation.

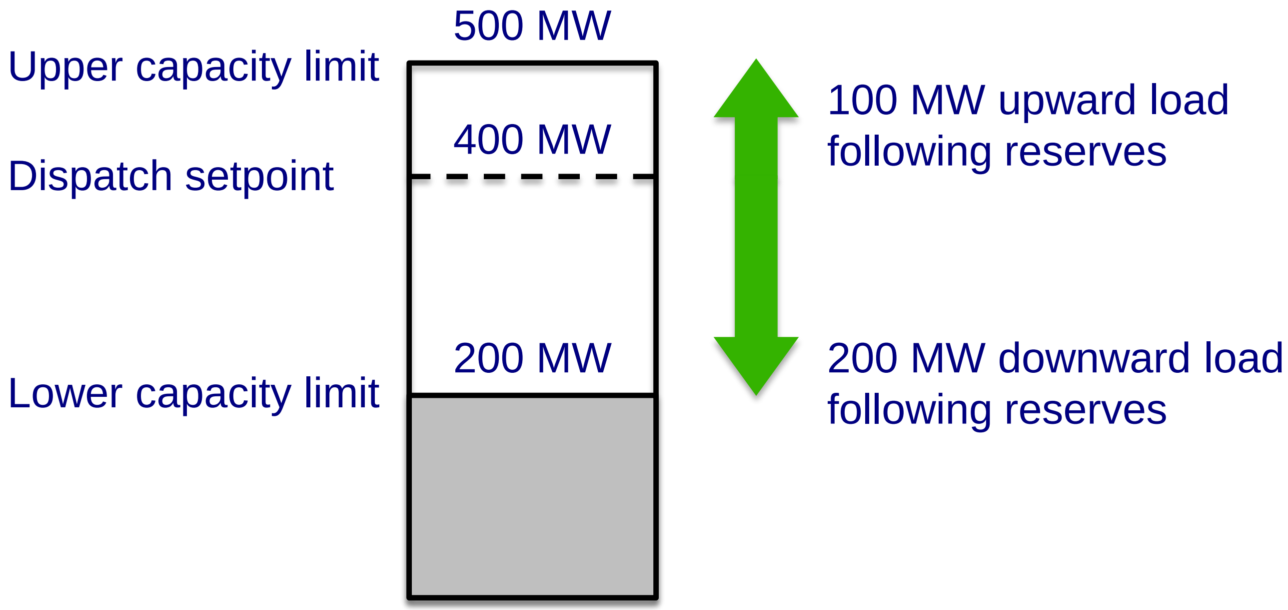
Operating Reserves: The ISO-NE View



∴ **The ISO-NE view on operating reserves has a focus on contingencies.**

Load Following Reserves: Physical Quantity vs. Product

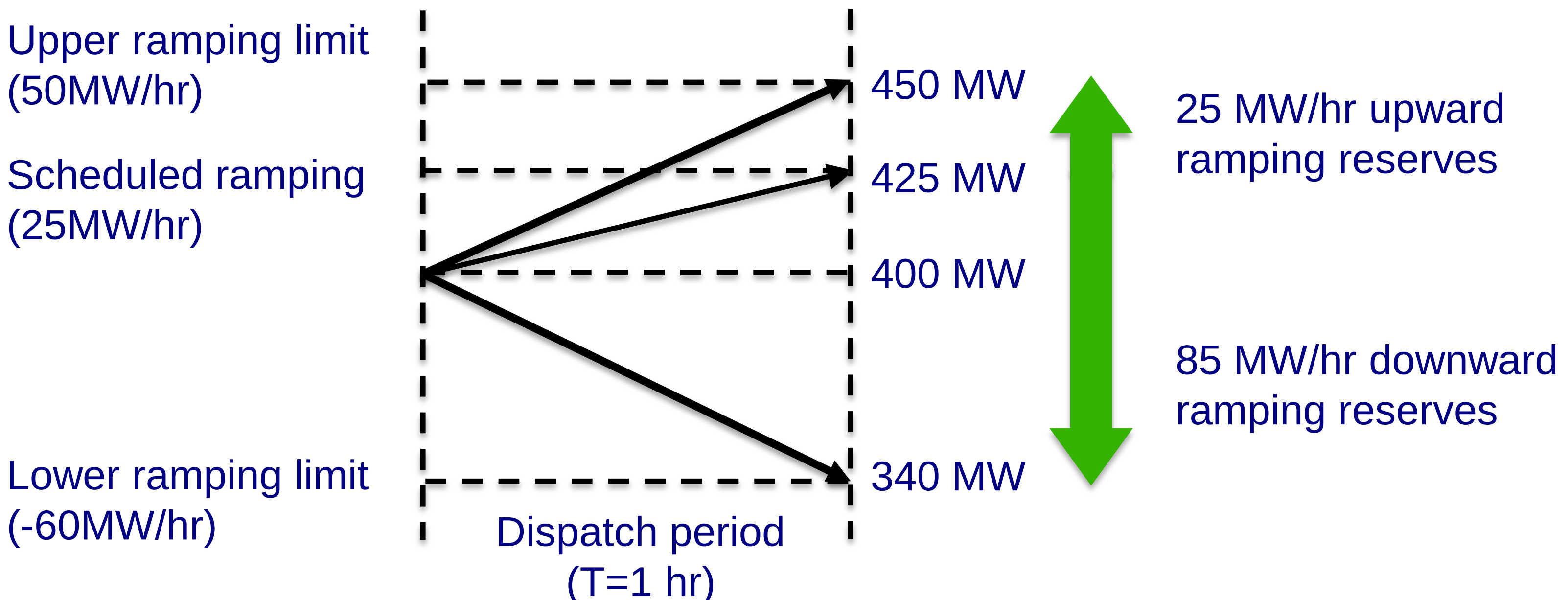
- Even in the absence of reserve requirements, the system still has load following reserves as a physical quantity.
- The quantity of load following reserves is equal to the excess capacity of the aggregate generation fleet to move up or down. (i.e. economic surplus)
- Currently, the ISO does not calculate this type of reserves.



∴ Load following reserves, as a physical quantity, assist Renewable Energy integration.

Ramping Reserves: Physical Quantity vs. Product

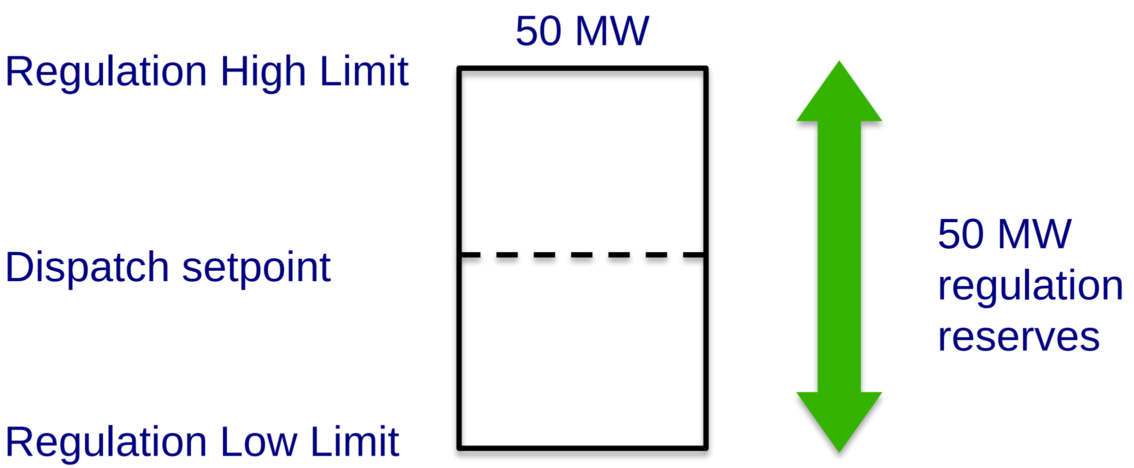
- Even in the absence of reserve requirements, the system still has ramping reserves as a physical quantity.
- The quantity of ramping reserves is equal to the excess ramping capability of the aggregate generation fleet to move up or down in time.
- Currently the ISO does not calculate this type of operating reserve.



∴ Ramping reserves, as a physical quantity, assist Renewable Energy integration.

Regulation Reserves: Physical Quantity vs. and Product

- Procurement of regulation reserves is done separately from the day-ahead unit commitment.
- The ISO procures regulation reserves according to their requirement.



∴ The physical quantity and the product match in the case of regulation reserves.

Reconciliation of Operating Reserves Definition

In light of these concepts, this project makes the following reconciliation:

- **Regulation Reserves**: There is no conceptual change in the understanding of regulation reserves for this study.
- **Ten Minute Spinning Reserves & Load Following Reserves**:
  - The ten-minute spinning reserves (TMSR) is provided by online resources able to increase their output within 10 minutes.
  - While the system will continue to require a TMSR to recover quickly from a significant system contingency, a high penetration of variable energy resources could cause the need to change how the TMSR is used. This could cause this quantity to be significantly increased.

Reconciliation of Operating Reserves: Example

A Motivating Hypothetical Example:

- Consider a hypothetical scenario in New England on a year where the peak load is 25GW. A 40% penetration of variable energy resources would equate to 10GW. If 50% of these VERS were to drop out quickly (beyond the forecast), there would be a 5GW shortfall. This is significantly larger than the largest single-facility contingency in the system.
- Therefore, there would be a need to for sufficient load following reserves, as a physical quantity, to address such a situation. In the absence of a new reserve type, the TMSR can be increased so as to respond to both single-facility contingencies as well as the variability and forecast error of variable energy resources.

Reconciliation of Operating Reserves Definition

In light of these concepts, this project makes the following reconciliation:

- **Non-spinning reserves**: The two non-spinning reserve requirements will remain unchanged. VER integration is fundamentally a normal operation phenomena. Non-spinning reserves only protect the system in the event of a loss of generation but do not protect the system in the event of an excess of generation. Furthermore, the variability of renewable energy generation means that a system with a negative imbalance can quickly switch to a system with a positive imbalance. Therefore, it is inadvisable to try to protect the power system from VER variability and forecast error only with non-spinning reserves.

Reconciliation of Operating Reserves Definition

In light of these concepts, this project makes the following reconciliation:

- **Ramping reserves**: Finally, in the case of ramping reserves, currently there is no requirement in ISO New England that provides an effective equivalent. This study will determine the needed quantities of ramping reserves for the study's scenarios. Such results might provide useful context as the resource mix continues to evolve.

ISO-NE Characteristics of Day Ahead Unit Commitment

Serves to commit generation, commit storage, and schedule reserves. Implements a security constrained unit commitment (SCUC).

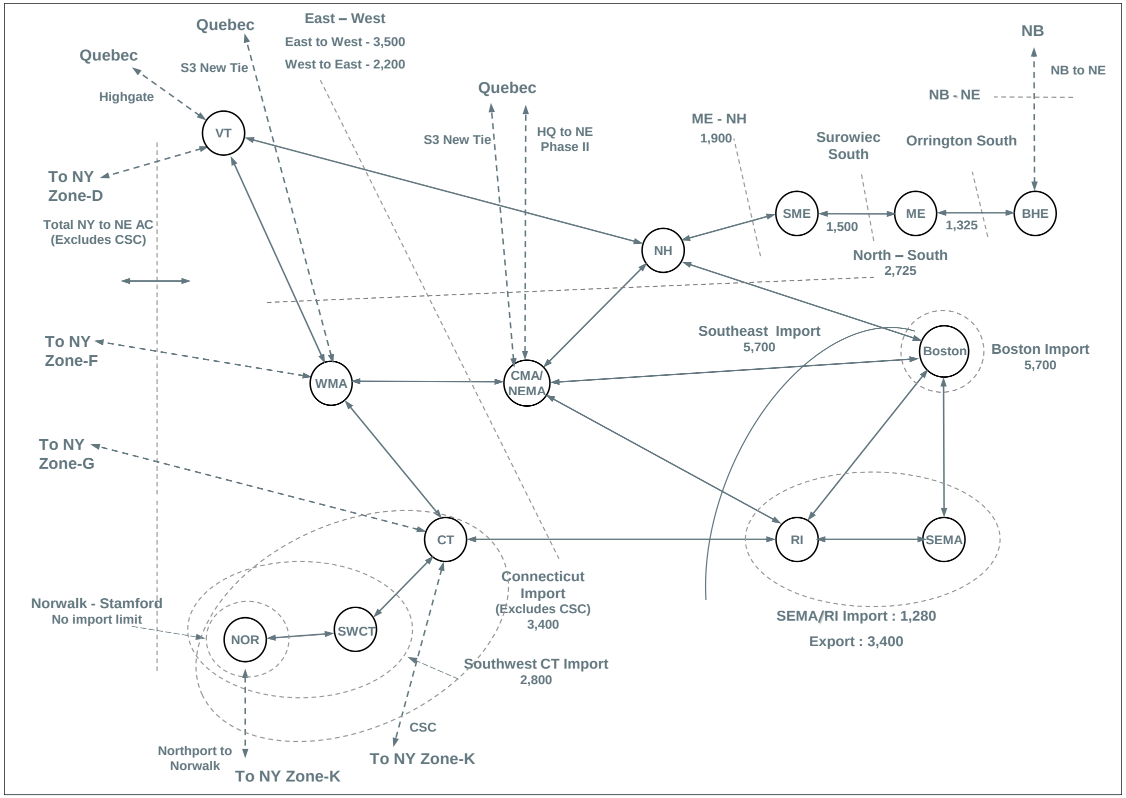
- **Objective Function**: Quadratic cost curve based on offer curve & include no-load cost & start-up cost
- **Generators**:
  - Minimum up & down time constraints
  - Ramp up & down constraints
  - Initial online hours, scheduled outages, self-schedules, maximum # of start up in a day
- **Pumped Storage**:
  - Maximum daily energy constraints
  - Maximum draw down
- **Operating Reserves**:
  - 10 minute & 30 minute reserves

∴ **The EPECS mimics ISO New England's Operations**

ISO-NE Characteristics of Day Ahead Unit Commitment

Serves to commit generation, commit storage, and schedule reserves

- **Topology**:
  - Zonal network (Pipe & Bubble) model including external transactions



[9]

∴ **The EPECS mimics ISO New England's Operations**

ISO-NE Characteristics of Same Day Unit Commitment

Serves to commit *fast-start* generation, commit storage, and schedule reserves. Implements a real-time unit commitment (RTUC). Similar to Day-Ahead Unit Commitment with several differences:

- **Time Intervals**: 14 intervals spanning 4-hour period
- **Decision Scope**: Commitment On/Off of fast start units
- **Forecast**: Short term system load
- **Reserves**: Imposes system and zonal requirements

∴ **The EPECS mimics ISO New England's Operations**

Characteristics of Real-Time Balancing Dispatch

Serves to dispatch generation, dispatch storage, procure regulation. Implements a security constrained economic dispatch (SCED). Similar to Day-Ahead Unit Commitment with several differences

- **Objective Function**: Based upon incremental linear cost curve
- **Operating Reserves**:
  - Reserve constraint penalty factors are considered
  - System and zonal reserve requirements
- **Time Window**: One 15 minute look-ahead window simulated
- **Initial Conditions**:
  - Initial state of a unit
  - Start up/ Shut down instructions from RTUC
- **Regulation Units:** Dispatched according to regulation parameters

∴ **The EPECS mimics ISO New England's Operations**

Characteristics of Physical Power Grid & Regulation

This model is a pseudo-steady-state model with 1 minute time resolution.

- **Physical Power Grid**: Implements a power flow analysis with imbalances measures in MW on a swing bus (representing NYISO)
- **Regulation Service:** Steady state approximation of a traditional frequency stability automatic generation control model.

∴ **The EPECS mimics ISO New England's Operations**

Demonstration of EPECS Simulator on the IEEE RTS-96 Test Case

We now demonstrate the EPECS Simulator on the IEEE Reliability Test System 1996 (RTS). This is a ***hypothetical*** test case with ***hypothetical*** data. It includes:

- Three areas tied together by five tie-lines (four 230 kV and one 138 kV)
- 70 buses
- 3 bus zones
- 99 generating units
- 73 loads with a peak load of 8550 MW

∴ IEEE Test Cases can be used to demonstrate the types of output results that the EPECS simulator generators

EPECS Simulator Outputs

The EPECS Simulator produces the following outputs:

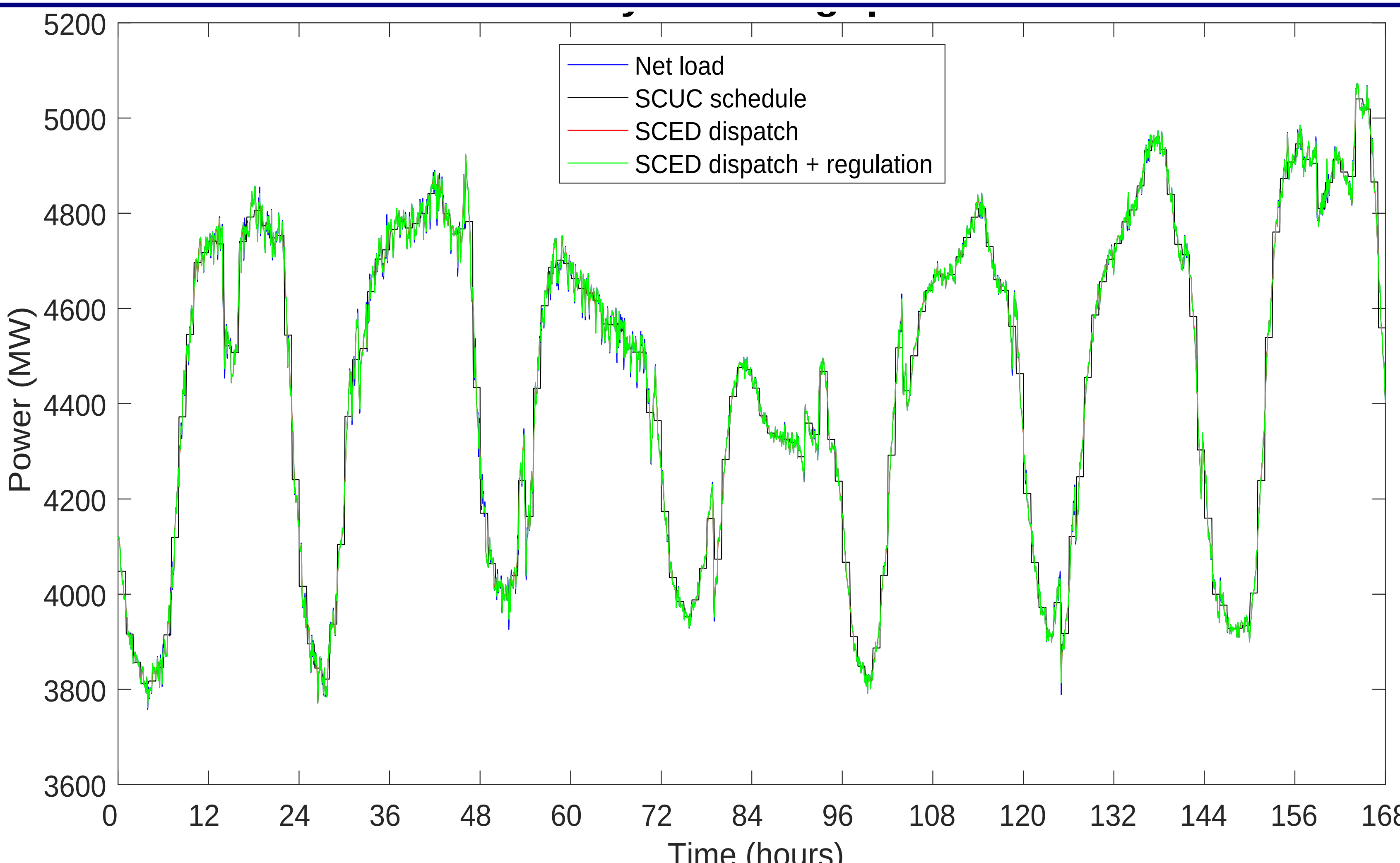
- Summary of Balancing Operations
- Security Constrained Unit Commitment Schedule
- Security Constrained Economic Dispatch
- Regulation & Imbalance Levels
- Load Following & Ramping Reserves Levels

For demonstration purposes only:

- The simulation is run for 1 week (rather than 1 year)
- The real-time unit commitment is left out.
- No forecast errors included on SCUC and SCED.

∴ IEEE Test Cases can be used to demonstrate the types of output results that the EPECS simulator generators

EPECS Simulator Outputs: Summary of Balancing

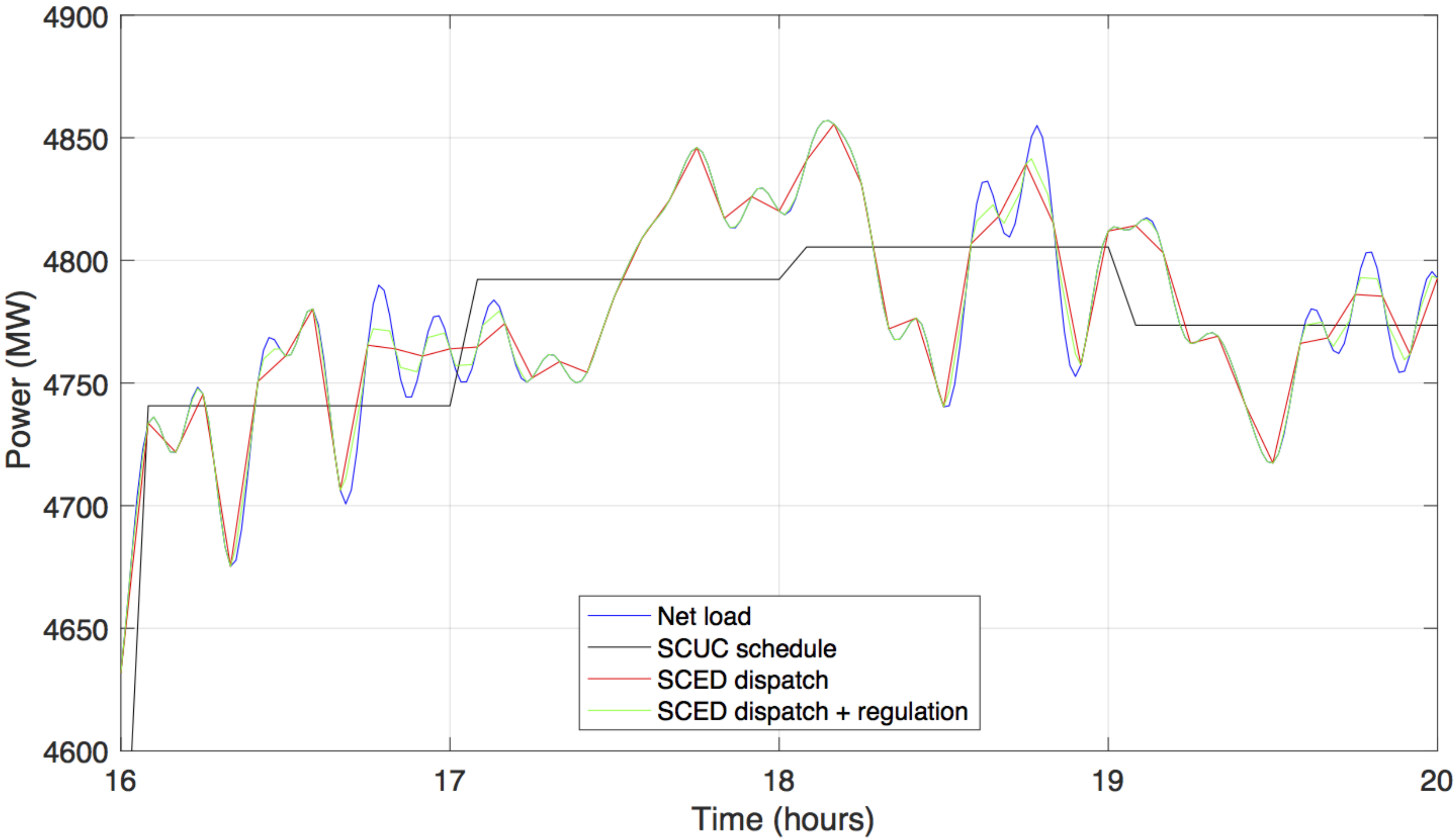


∴ **The three time series track the net load with different levels of accuracy.**

THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

LIINES LABORATORY FOR INTELLIGENT INTEGRATED NETWORKS OF ENGINEERING SYSTEMS EMPOWERING YOUR NETWORK

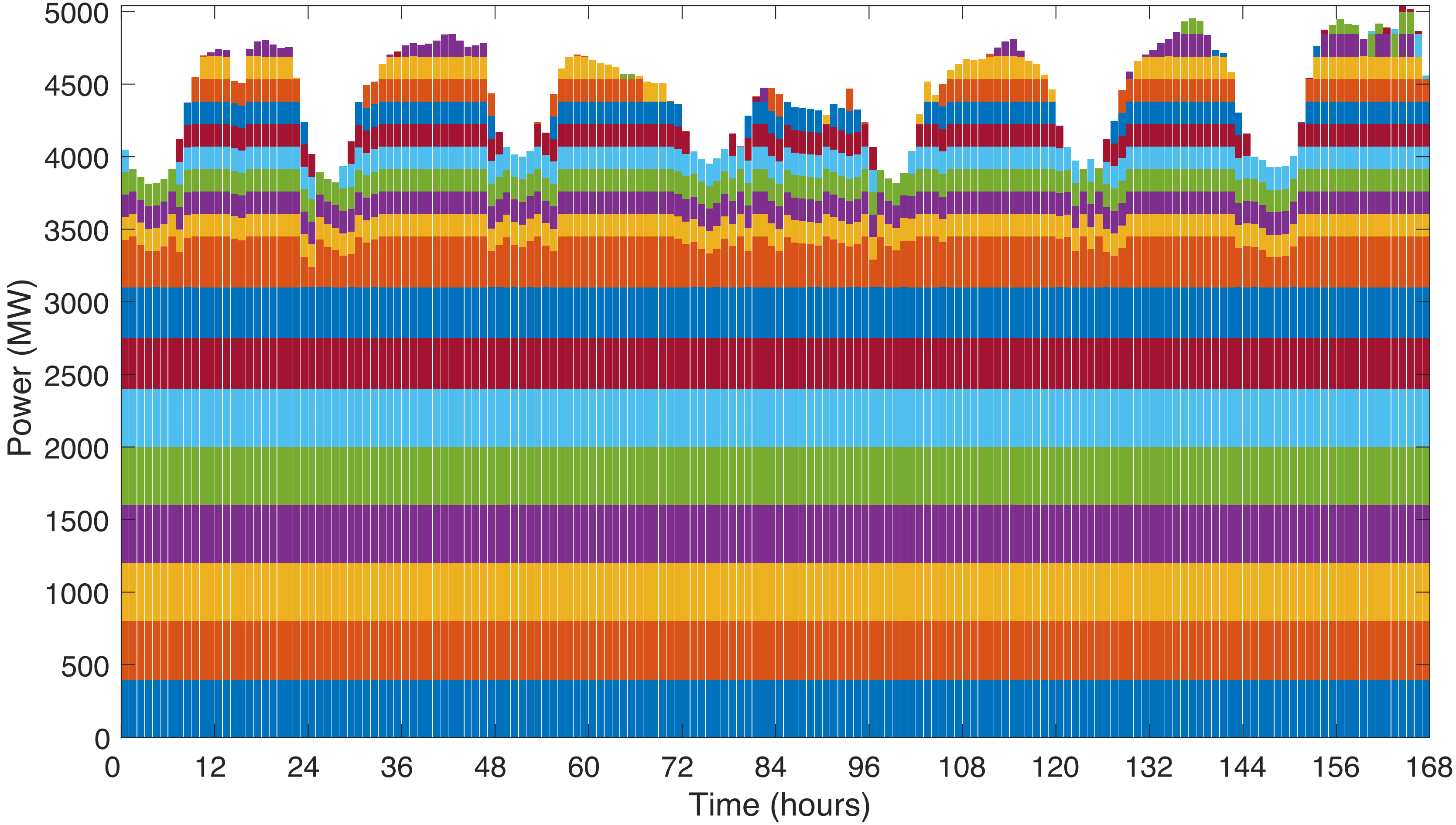
EPECS Simulator Outputs: Summary of Balancing



∴ **The three time series track the net load with different levels of accuracy.**

EPECS Simulator Outputs: SCUC Schedule

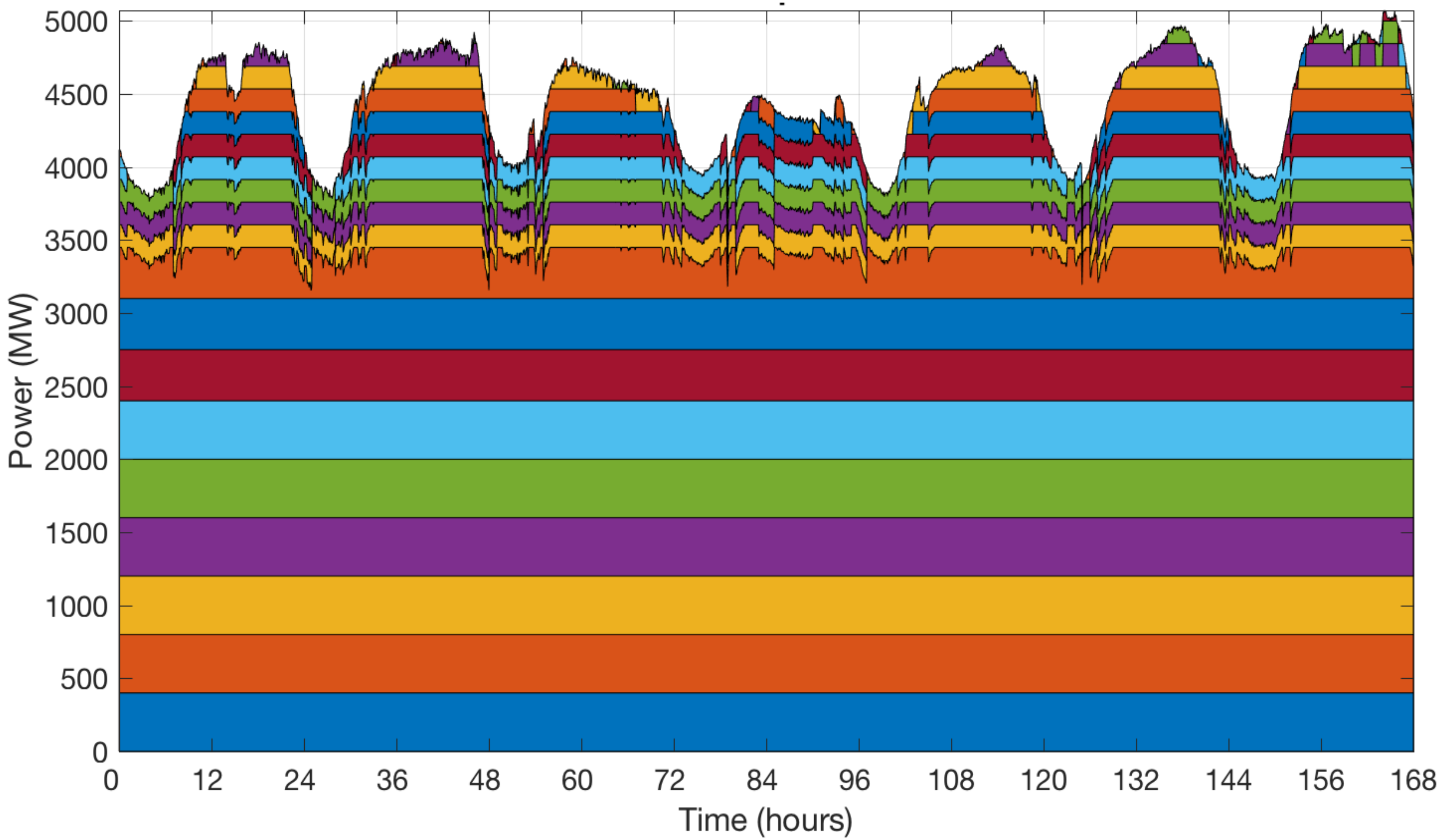
Each color represents how much power is produced by generation facilities.



∴ **Shows the SCUC economic merit order for 1 week and 1hr resolution.**

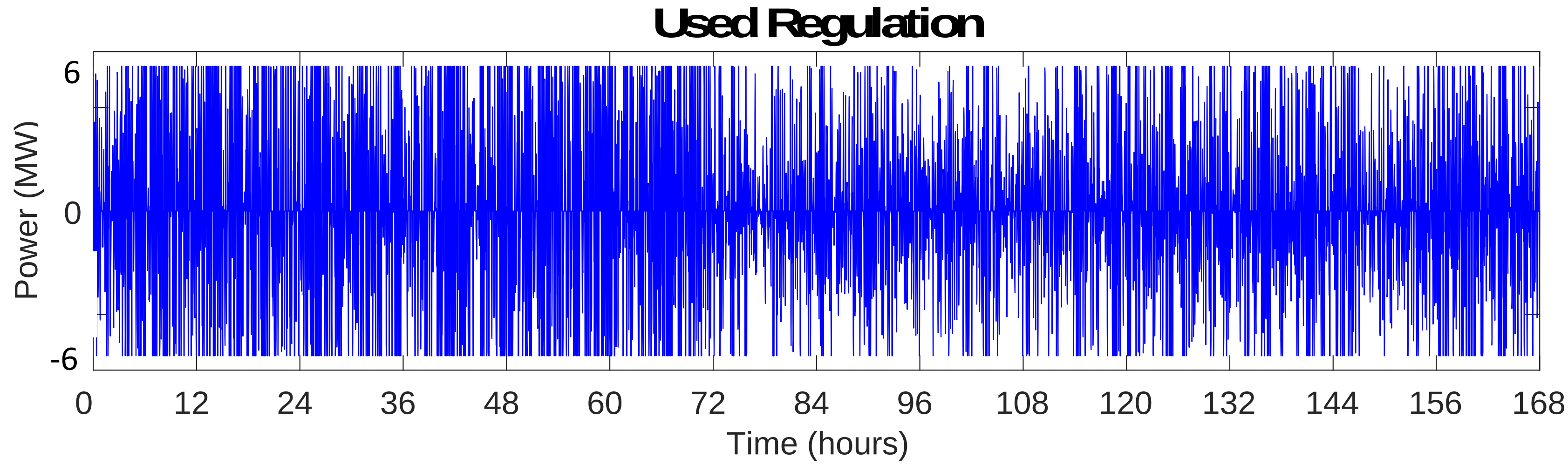
EPECS Simulator Outputs: SCED Schedule

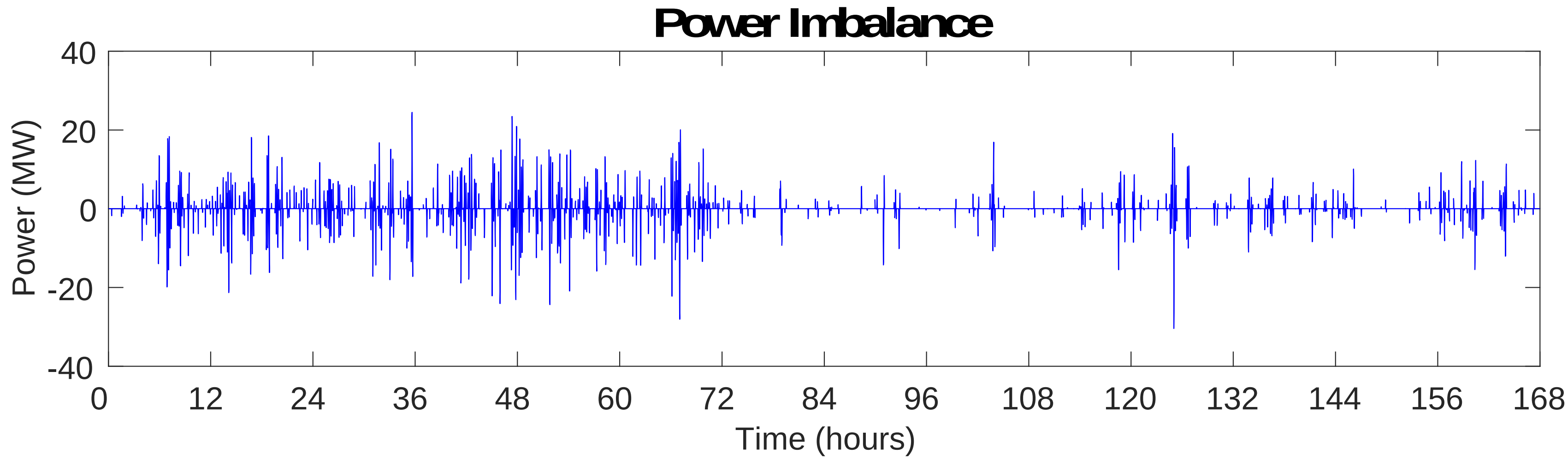
Each color represents how much power is produced by generation facilities.



∴ **Shows the SCED economic merit order for 1 week and 5min resolution.**

EPECS Simulator Outputs: Regulation & Imbalances



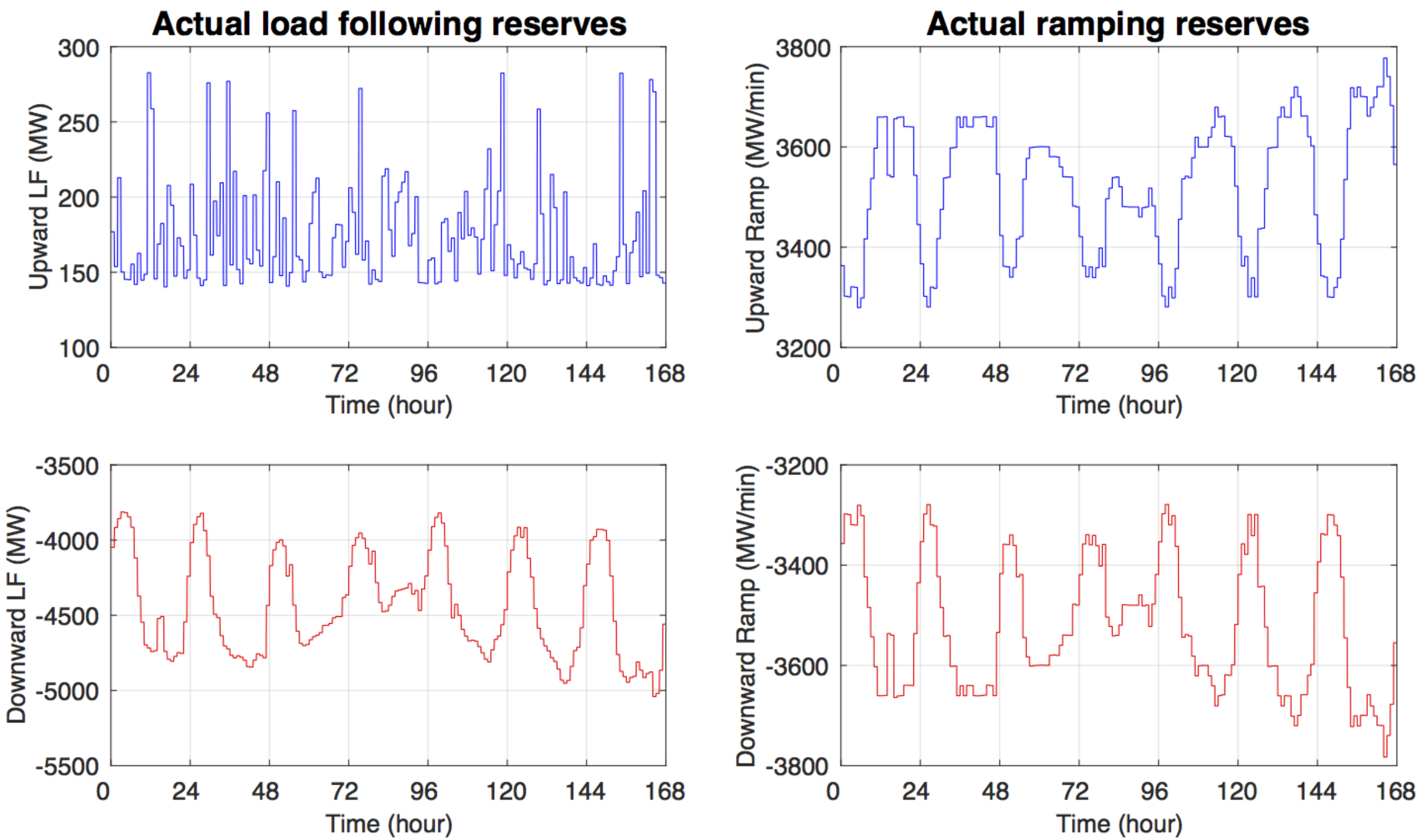


∴ 6 MW of Regulation reserves is insufficient, it leads restricts imbalances to generally within +/- 20 MW.

THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

LIINES LABORATORY FOR INTELLIGENT INTEGRATED NETWORKS OF ENGINEERING SYSTEMS EMPOWERING YOUR NETWORK

EPECS Simulator Outputs: Reserve Levels



∴ **Reserve levels change with commitment decisions & net load variability.**

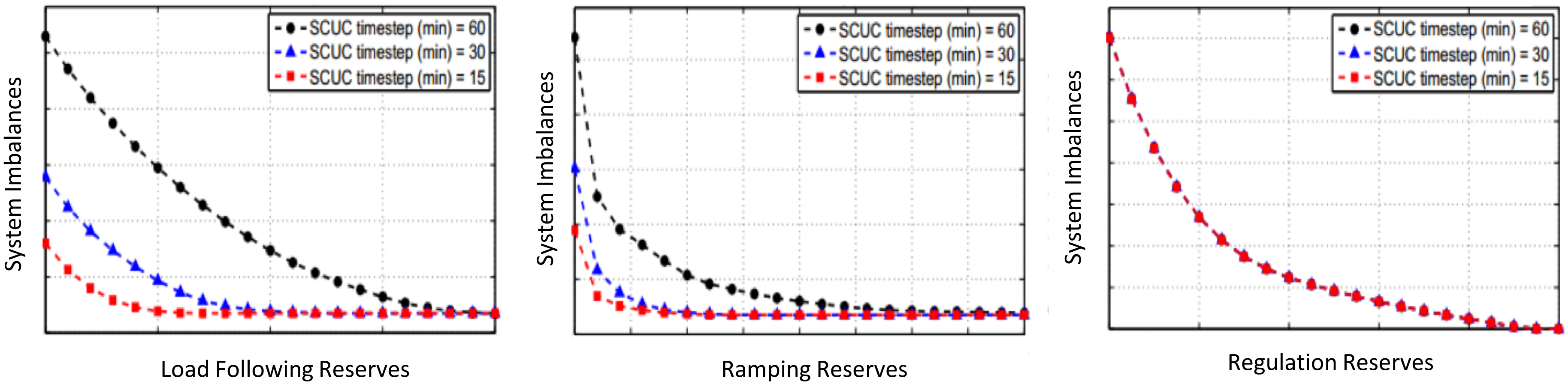
EPECS Simulation: Assessment of Operating Reserves

The EPECS Simulator can be used to assess operating reserves as a parametric sensitivity analysis. Here, we again use the IEEE RTS-96 test case to demonstrate expected results:

- Power system imbalances are studied systematically as a function of exogenous and endogenous parameters:
  - Day-ahead unit commitment time step
  - Real-time unit commitment time step
  - VER Variability
  - Day-ahead forecast error
  - Short-term forecast error

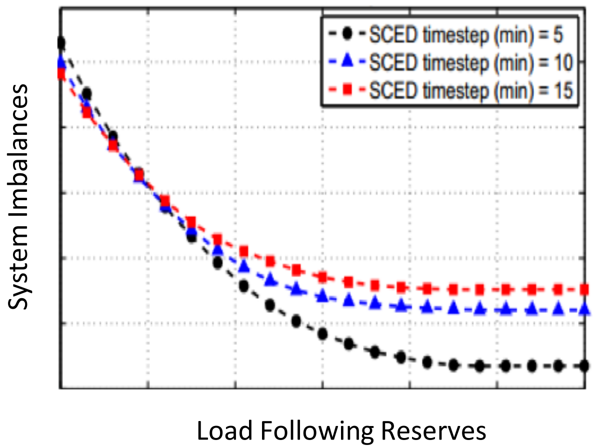
∴ Sensitivity analysis methodology clear shows performance trade-offs.

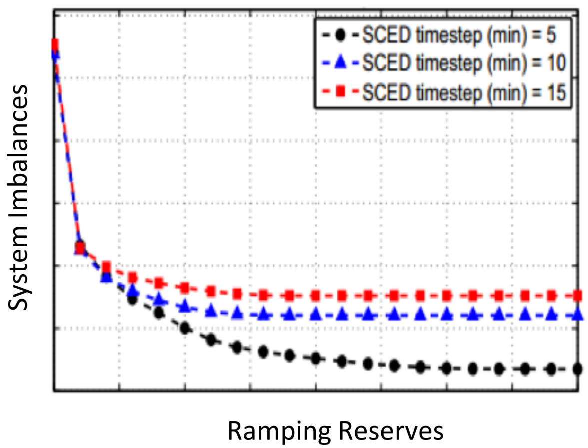
Impact of the Day-Ahead Unit Commitment Time Step

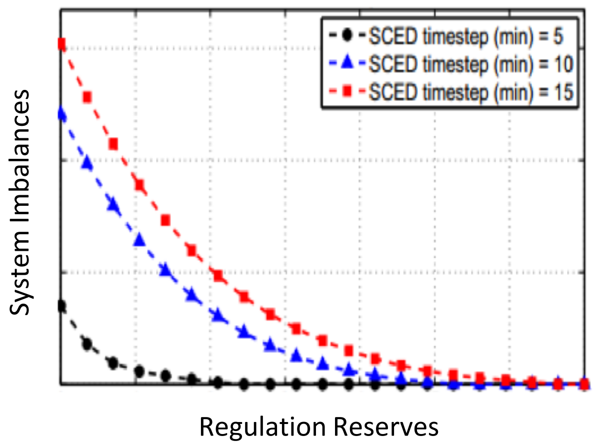


- At the same level of power system imbalances, a reduction of day-ahead unit commitment time step causes:
  - A reduction in the need for load following reserves (i.e. economic surplus reserves)
  - A reduction in the need for ramping reserves (i.e. aggregate generator flexibility)
  - No impact on the need for regulation reserves

Impact of the Real-Time Balancing Time Step

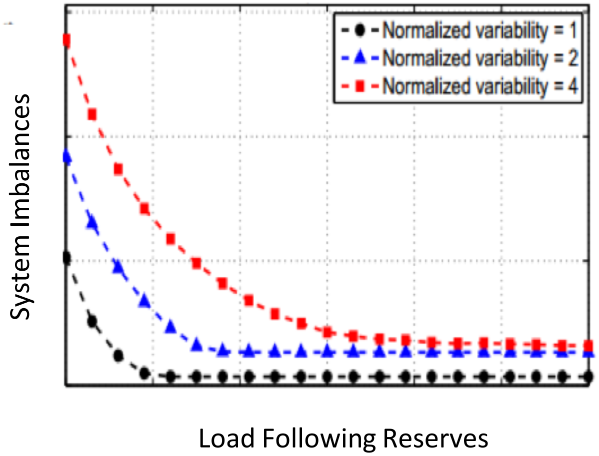


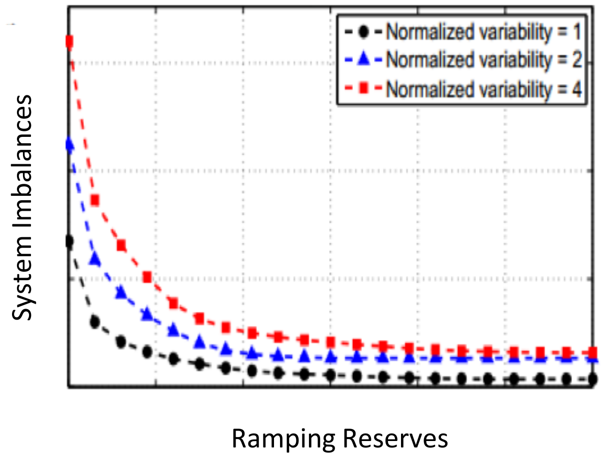


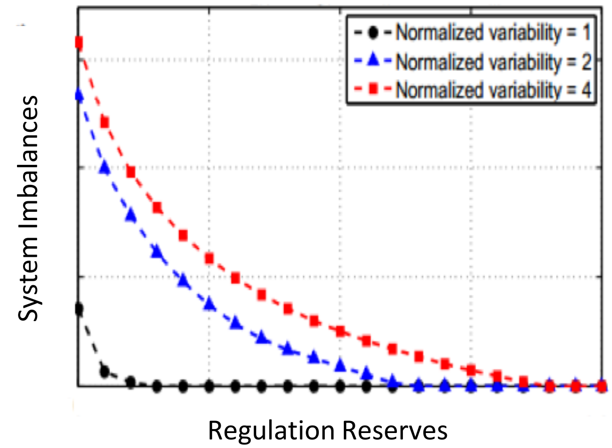


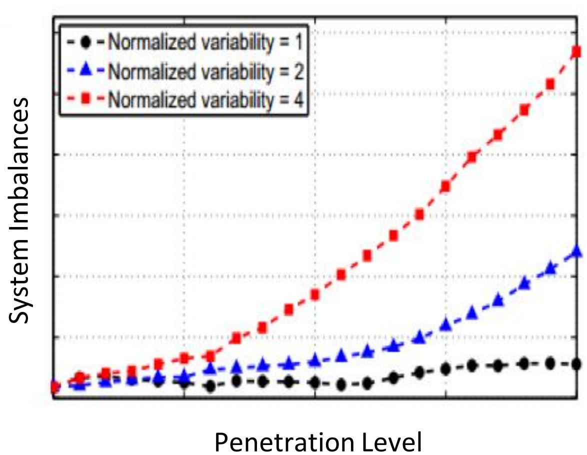
- At the same level of power system imbalances, a reduction of real-time balancing time step causes:
  - A reduction in the need for regulation reserves
  - No impact on the need for load following and ramping reserves

Impact of the VER Variability



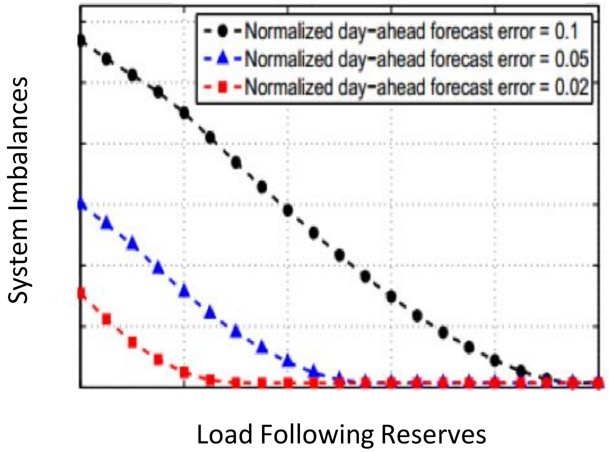


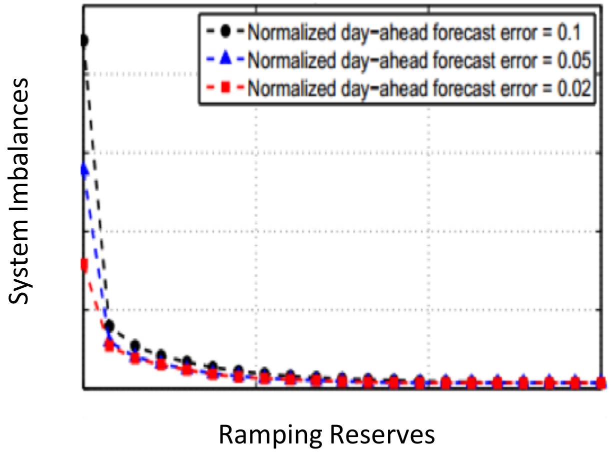


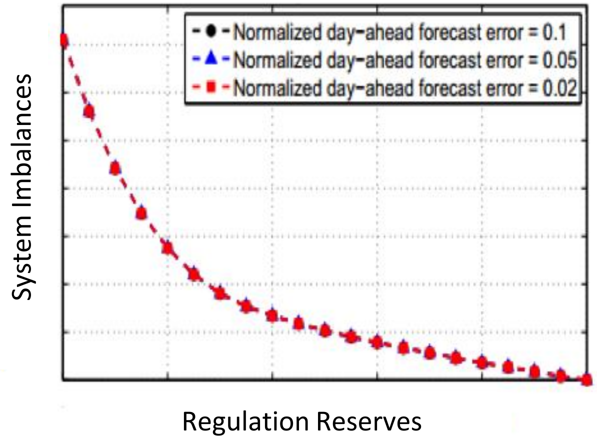


- VER penetration introduces greater imbalances at all time scales. → Additional reserves of all types
- VER variability introduces greater imbalances at all time scales. → Effect is compounded w/ greater penetration

Impact of the VER Day-Ahead Forecast Error

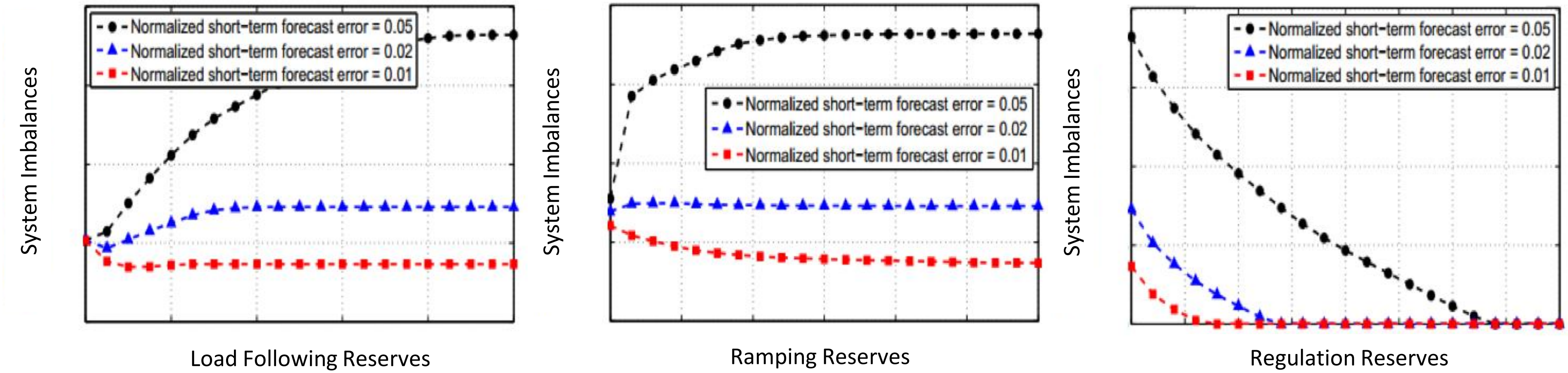






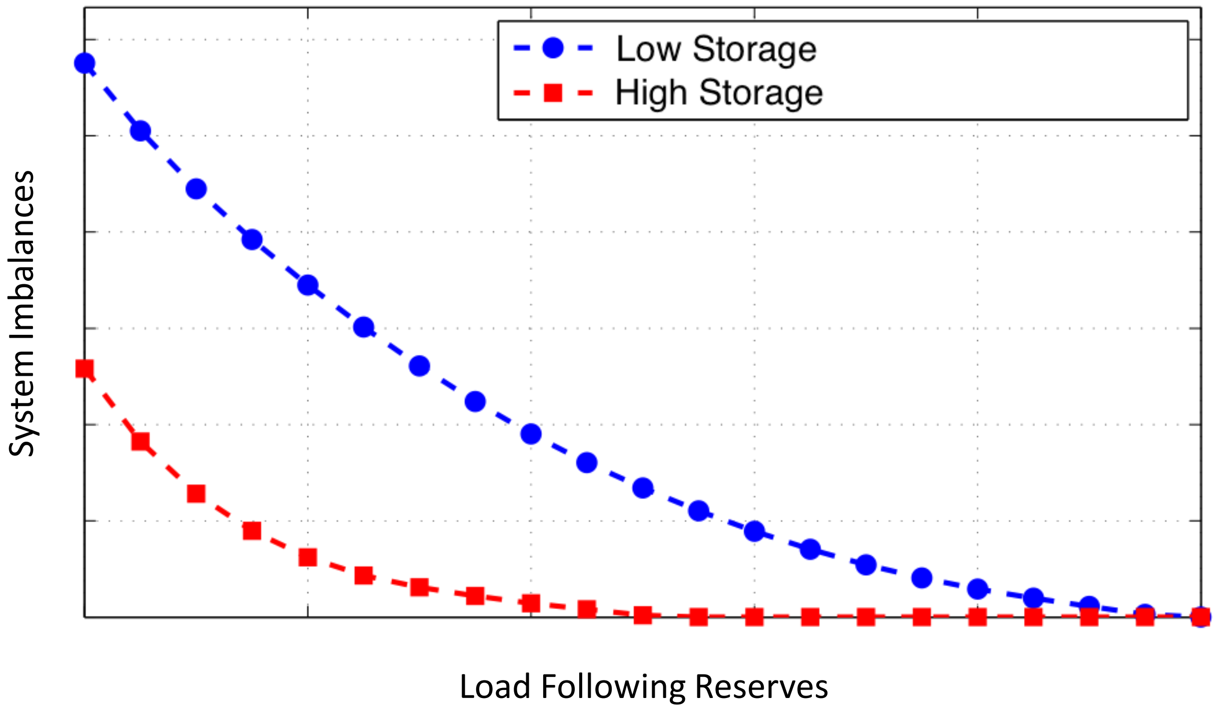
- Day-ahead forecast error increases the load following and ramping reserve requirement
- No impact on regulation reserves requirement

Impact of the VER Short-Term Forecast Error



- VER short term forecast error increases the regulation reserve requirement
- It causes no impact on the load following and ramping reserve requirements

Impact of Energy Storage vs. Load Following Reserves



∴ **Easy trade-offs can be made between energy storage & load following reserves**

Presentation Outline

Goal: To describe the methodology by which we will conduct the SOARES project (2017 ISO New England System Operational Analysis and Renewable Energy Integration Study)

- Need for Holistic Electric Power Enterprise Control Assessment
  - *As the electric generation mix in New England evolves in the coming years, the impacts on technical performance must be assessed within holistic frameworks that include exogeneous as well as endogeneous characteristics.*
- Electric Power Enterprise Control Simulation for ISO New England
  - *The Electric Power Enterprise Control Simulator (EPECS) can be used to assess how the ISO New England power system would respond to various electric generation mix scenarios.*
- **Methodology for Integrating EPECS into the SOARES Project**
  - *With the electric power enterprise control simulation in place, ISO New England can objectively assess power grid imbalances and the need for operating reserves within a single integrated environment.*

Integration of EPECS into SOARES Project

The EPECS simulator will be used to carry out the project scenarios described in the ISO-NE presentation.

Scenario	Retirements	Gross Demand	PV	Energy Efficiency	Wind	New NG Units	HQ and NB External Ties & Transfer Limits
1	½ in 2025 ½ in 2030	Based on 2016 CELT forecast	Based on 2016 CELT forecast	Based on 2016 CELT forecast	As needed to meet RPSs	NGCC	Based on historical profiles
2	½ in 2025 ½ in 2030	Based on 2016 CELT forecast	BTM based on 2016 CELT forecast; non-BTM same as wind	Based on 2016 CELT forecast	Used to satisfy net ICR	None	Based on historical profiles
3	½ in 2025 ½ in 2030	Based on 2016 CELT forecast	8,000 MW (2025) 12,000 MW (2030) BTM PV 4,000 (2025) 6,000 (2030) Utility PV 4,000 (2025) 6,000 (2030)	4,844 MW (2025) 7,009 MW (2030)	5,733 MW (2025) 7,283 MW (2030)	None	Based on historical profiles plus additional imports
4	No retirements beyond FCA #10	Based on 2016 CELT forecast	Based on 2016 forecast	Based on 2016 forecast	Existing plus those with I.3.9 approval	NGCC	Based on historical profiles
5	½ in 2025 ½ in 2030	Based on 2016 CELT forecast	Based on 2016 CELT forecast	Based on 2016 CELT forecast	Existing plus those with I.3.9 approval	NGCC	Based on historical profiles
6	½ in 2025 ½ in 2030	Based on 2016 CELT forecast	381 MW (2025) 1,611 MW (2030)	Based on 2016 CELT forecast	Onshore wind: 381 MW (2025) 1,611 MW (2030) Offshore wind: 381 MW (2025) 1,611 MW (2030)	None	Based on historical profiles

Project Time Table

As mentioned in ISO-NE presentation, the project will proceed as follows:

- August 3, 2017 – Today's presentation on methodology
- December 20, 2017 – PAC presentation on Scenario Results
- Q1 2018 – Final Report

References -- Keep a lookout for the ISO's draft report.

- [1] -- ISO-NE, "2014 ISO New England Electric Generator Air Emissions Report," , ***ISO New England Inc. System Planning***, January 2016.
- [2] -- ISO-NE, "2015 ISO New England Electric Generator Air Emissions Report,"., ***ISO New England Inc. System Planning***, January 2017.
- [3] A. M. Farid, B. Jiang, A. Muzhikyan, and K. Youcef-Toumi, "The Need for Holistic Enterprise Control Assessment Methods for the Future Electricity Grid," **Renewable & Sustainable Energy Reviews**, vol. 56, no. 1, pp. 669–685, 2015.
- [4] A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "*An A Priori Analytical Method for Determination of Operating Reserves Requirements*," ***International Journal of Energy and Power Systems***, vol. 86, no. 3, pp. 1–11, 2016.
- [5] A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "An Enterprise Control Assessment Method for Variable Energy Resource Induced Power System Imbalances Part 2: Results," ***IEEE Transactions on Industrial Electronics***, vol. 62, no. 4, pp. 2459 – 2467, 2015.
- [6] Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "*An Enterprise Control Assessment Method for Variable Energy Resource Induced Power System Imbalances Part 1: Methodology*," **IEEE Transactions on Industrial Electronics**, vol. 62, no. 4, pp. 2448–2458, 2015.
- [7] A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "*An Enterprise Control Assessment Method for Variable Energy Resource Induced Power System Imbalances Part 2: Results*," **IEEE Transactions on Industrial Electronics**, vol. 62, no. 4, pp. 2459 – 2467, 2015.
- [8] A. Muzhikyan, A. M. Farid, and K. Youcef-Toumi, "*Relative Merits of Load Following Reserves and Energy Storage Market Integration Towards Power System Imbalances*," **International Journal of Electrical Power and Energy Systems**, vol. 74, no. 1, pp. 222–229, 2016.

References

- [9] "First Draft, 2016 Economic Study: NEPOOL Scenario Analysis," ISO New England Planning Advisory Committee, July 24, 2017, Figure 5-6, 39.
- [10] Holttinen, H., Milligan, M., Ela, et al, (2012). Methodologies to Determine Operating Reserves Due to Increased Wind Power. Sustainable Energy, IEEE Transactions on, 3(4), 713–723.

Thank You

QUESTIONS?