Flexible Ramping Products: An Introduction

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Pennsylvania State University

PJM Reserve Certainty Senior Task Force

October 16, 2024

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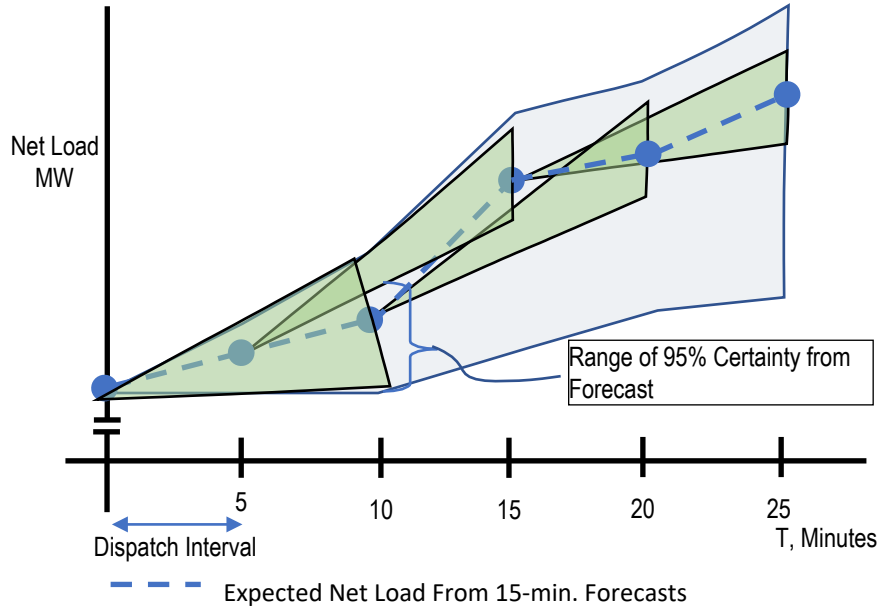
Overview of This Presentation

- Problem Statement
  - Why do we need this?
- Ramp Products:
  - How they work
  - Why they work
  - Design / Implementation choices
- Discussion: Potential future ramp product designs



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Features of PJM's Real-Time Markets

- Day-Ahead Market clears the previous day
  - The RAC* is performed just before the start of the operating day
- Real-Time Markets are cleared in a rolling horizon
  - Real-Time Unit Commitment* (IT-SCED)
    - Solved 30 minutes prior to target interval
    - 2-hour lookahead horizon
    - Results inform decisions to start-up more (Fast-Start) units
  - Real-Time Economic Dispatch (RT-SCED)
    - Solved 10 minutes prior to target interval
    - Single-interval dispatch (no lookahead)

** Advisory for operators*

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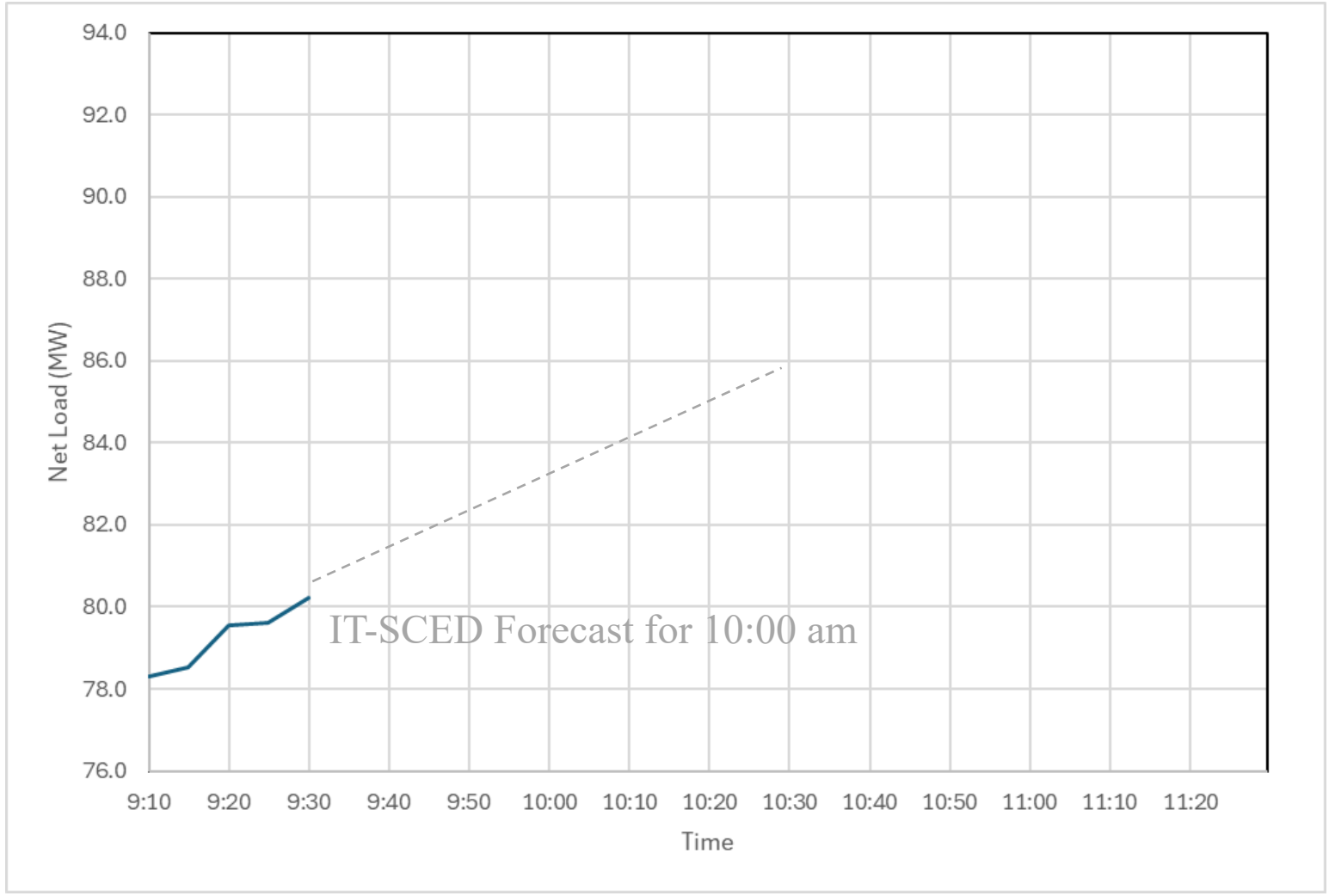
Illustration of Real-Time Market Sequence



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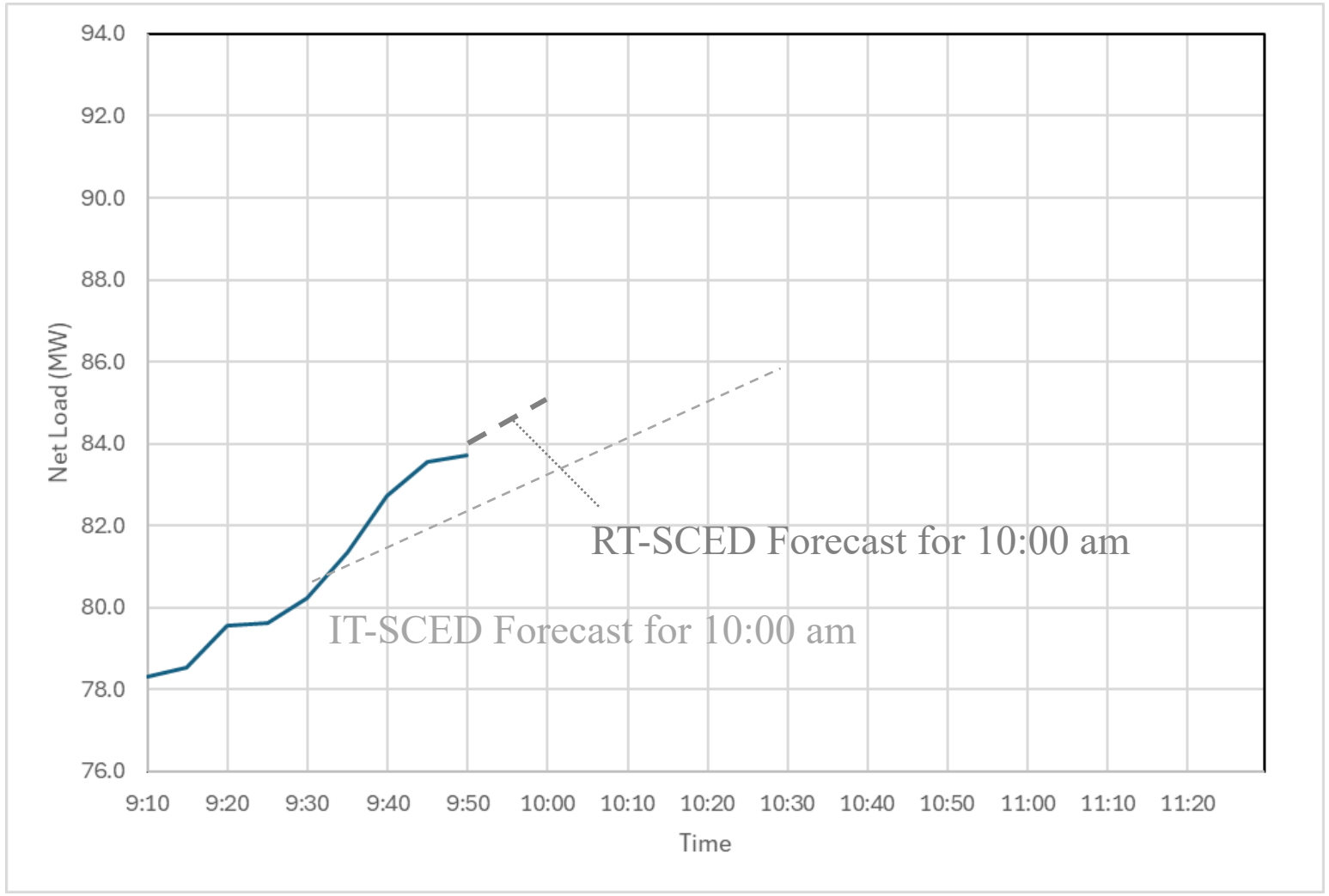

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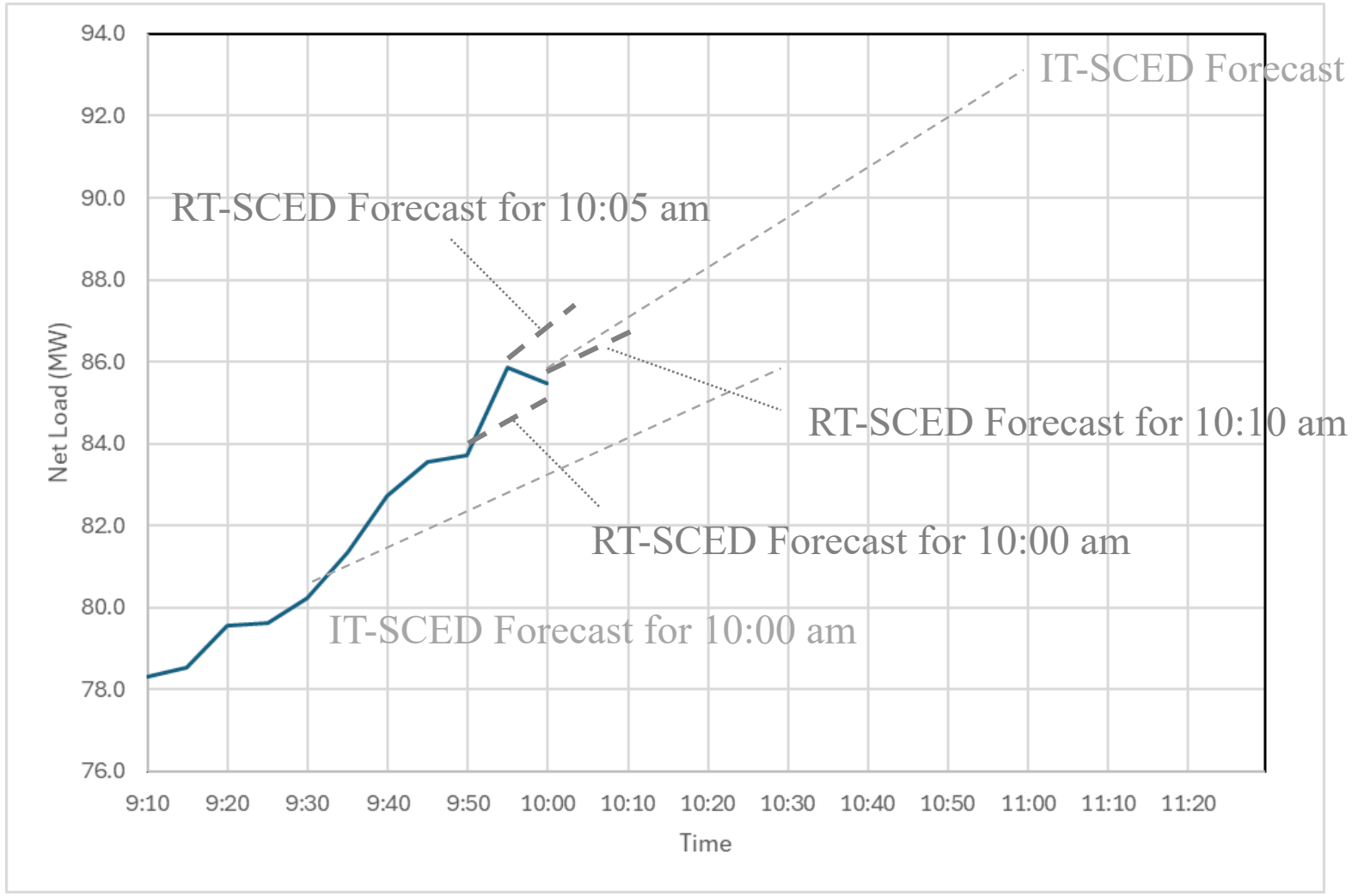

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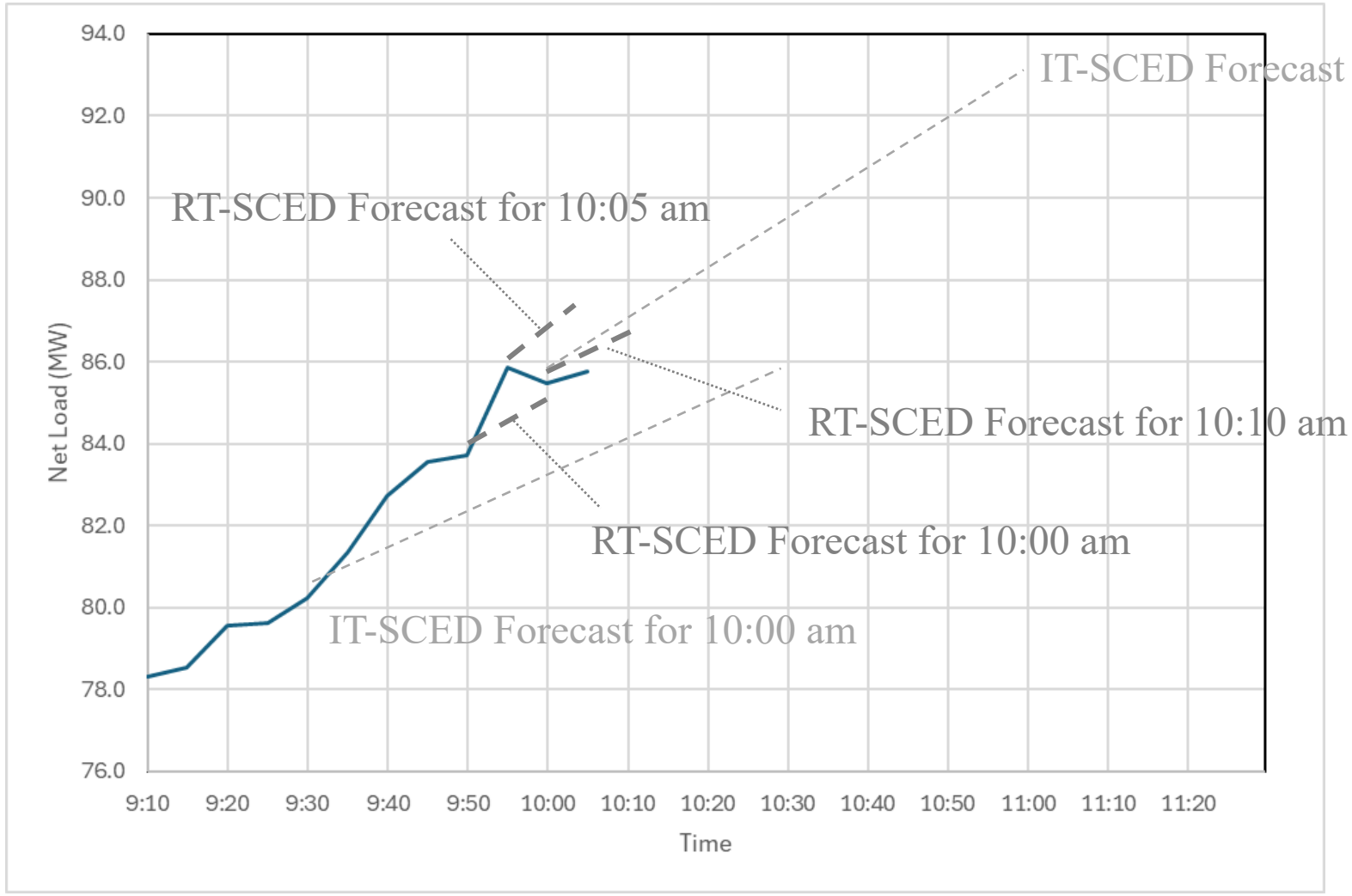

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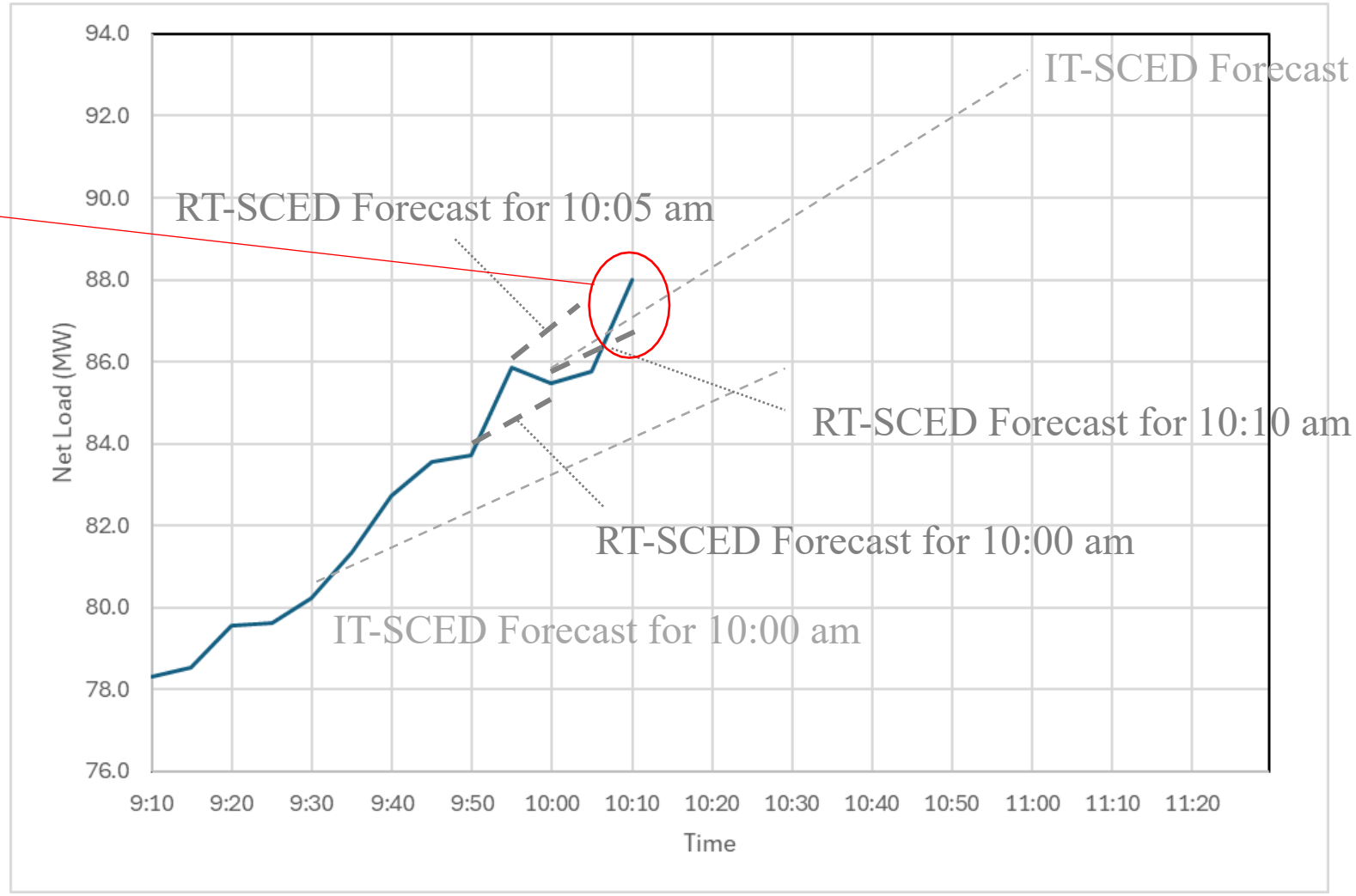
Unserved Energy!



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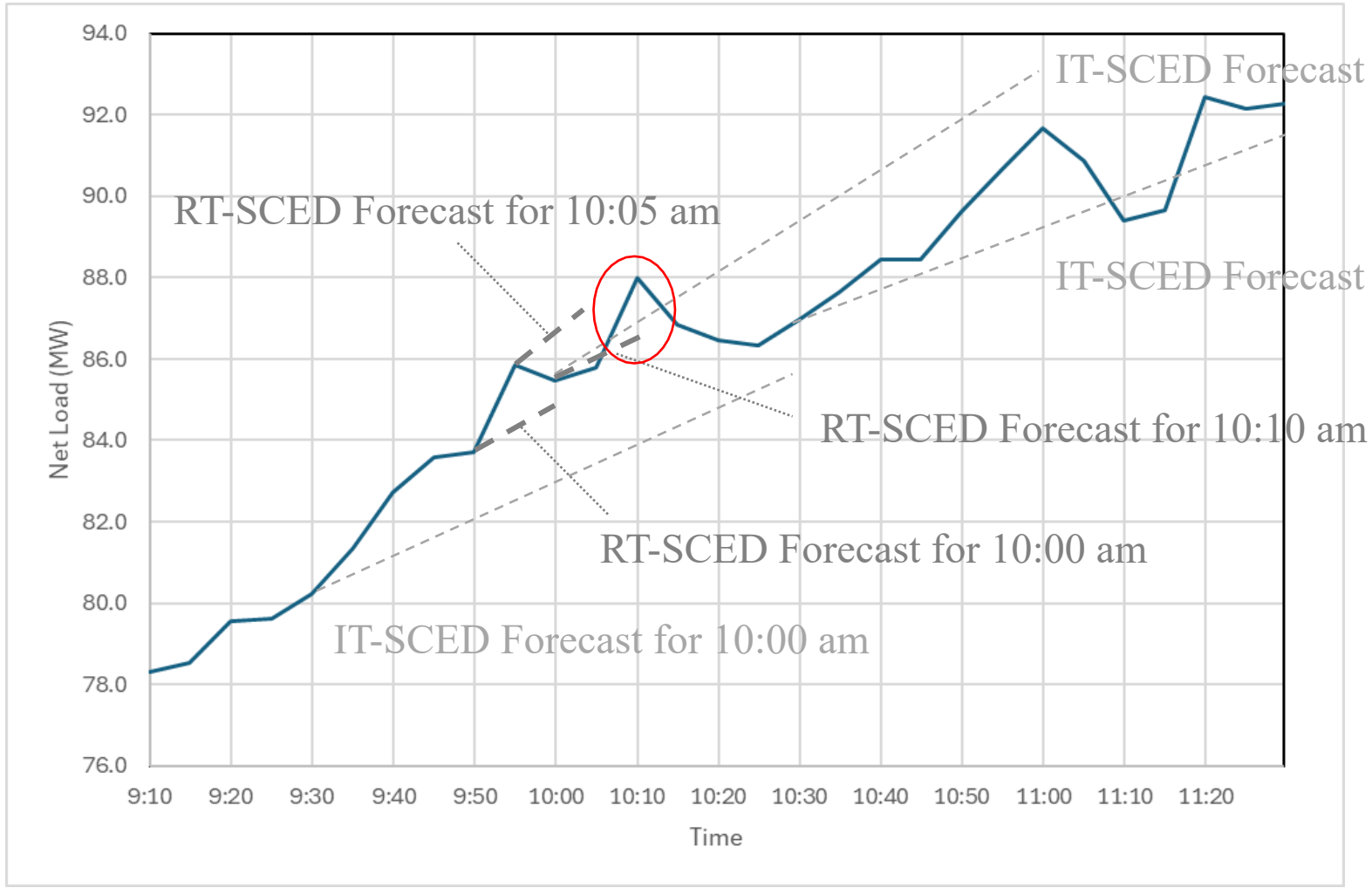

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Why a Need for "Ramping Capability"?

1. **Single-interval economic dispatch**

   Does not consider ramping capability beyond the target interval

2. Variability

   5-minute changes in net load may be larger than IT-SCED, DA forecasts

3. Forecast error

   The real-time load, wind, solar, and interchange may deviate from the 10-minute and 30-minute ahead forecasts

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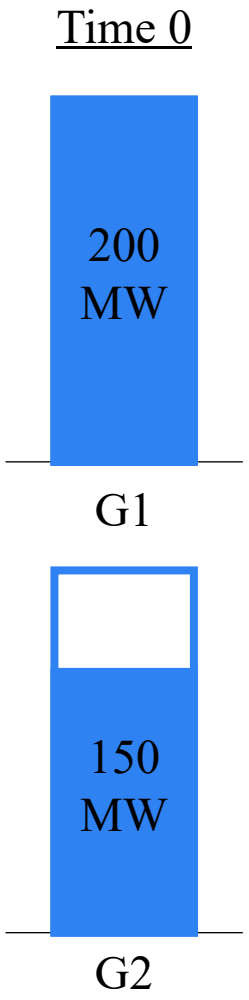
Illustrative Example: Single Interval Dispatch



Load = 350 MW

	G1	G2
ECOMIN	120	120
ECOMAX	200	200
Ramp Limit (5-min)	5	10
Marginal Cost	$30/MWh	$50/MWh

Adapted from materials by Dane Schiro, ISO-NE

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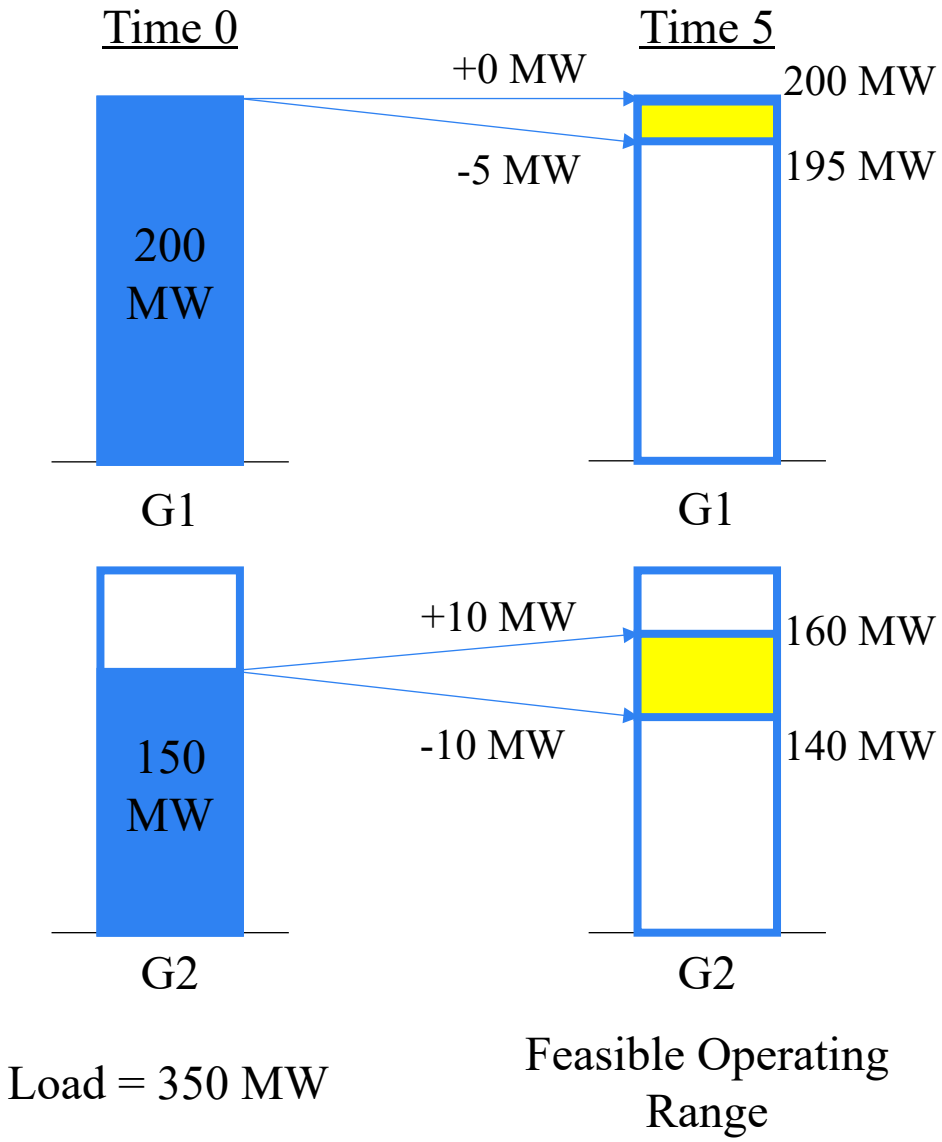

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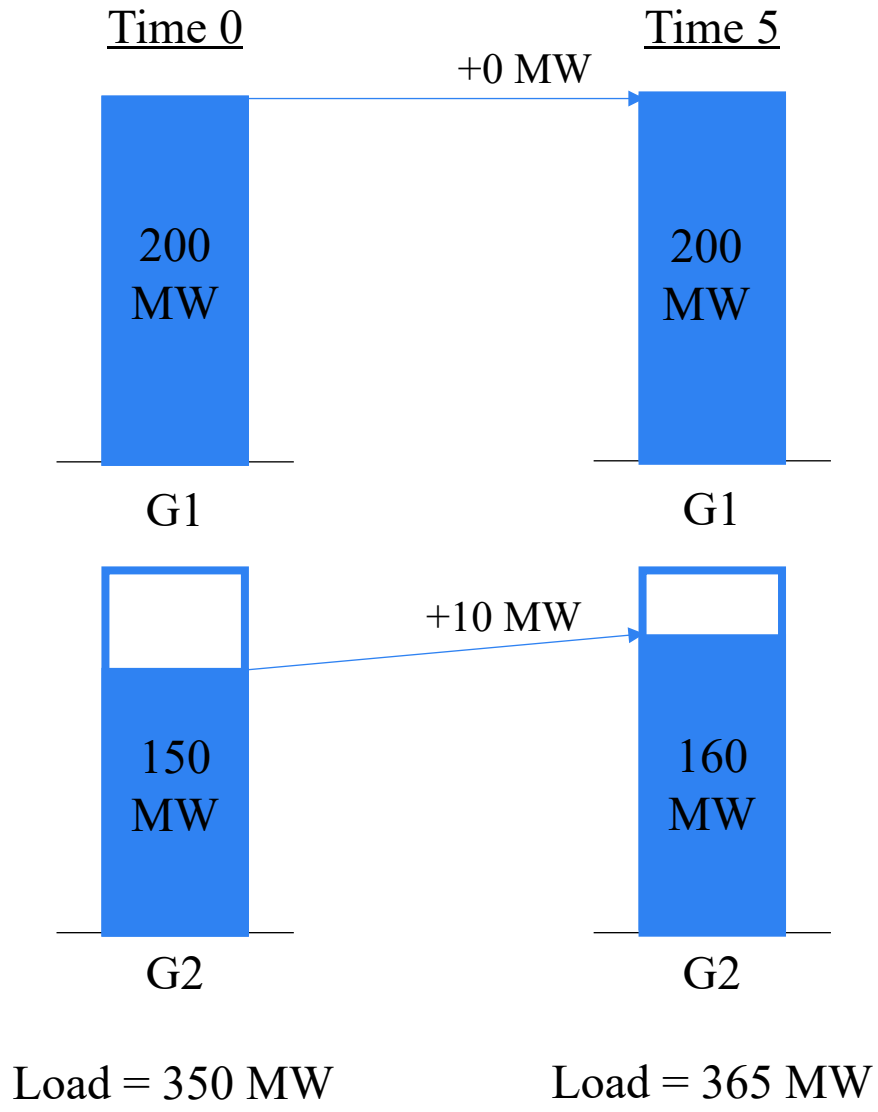

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5 MW Unserved Energy

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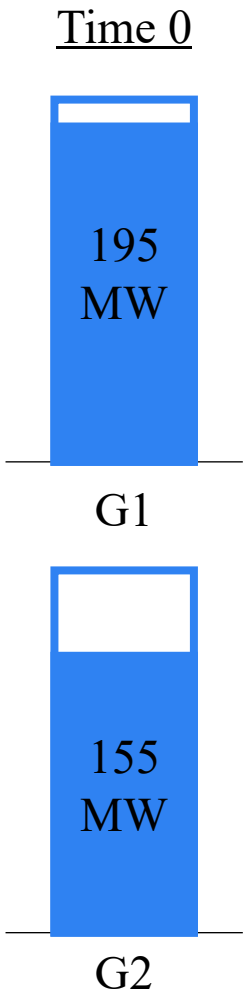
Illustrative Example: With Ramp Product



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Assume System Requirement:
15 MW of Up Ramp Capability

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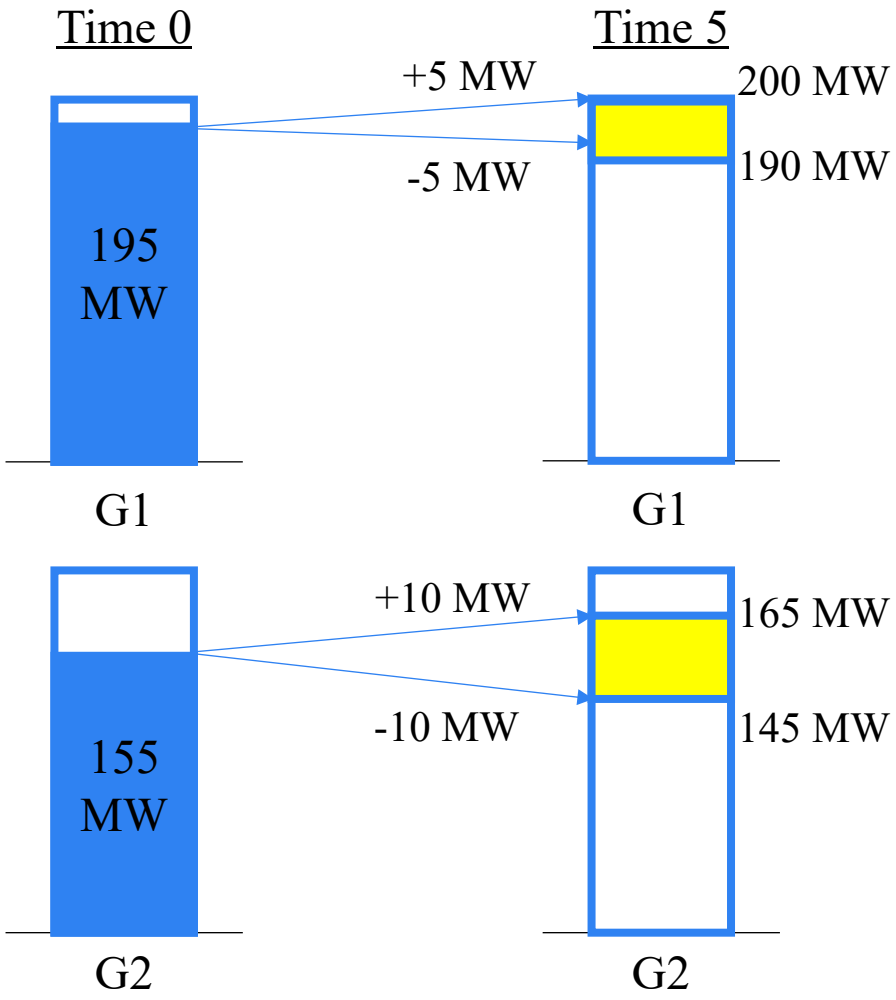

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Feasible Operating Range

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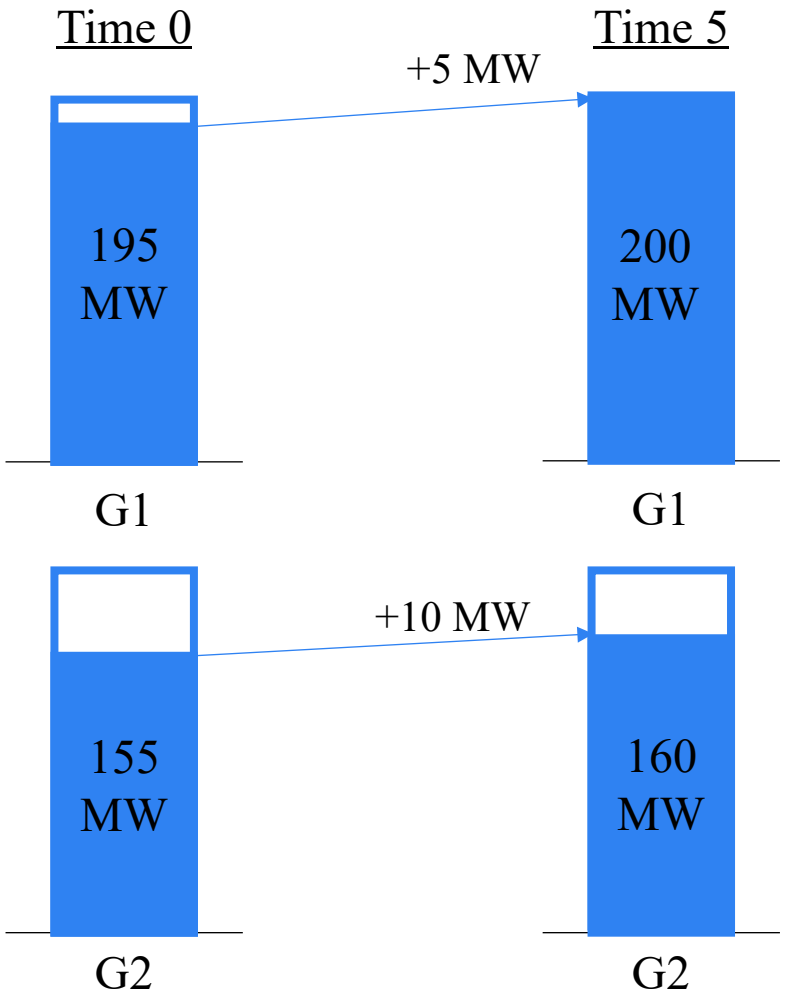

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All load is served at Time 5!

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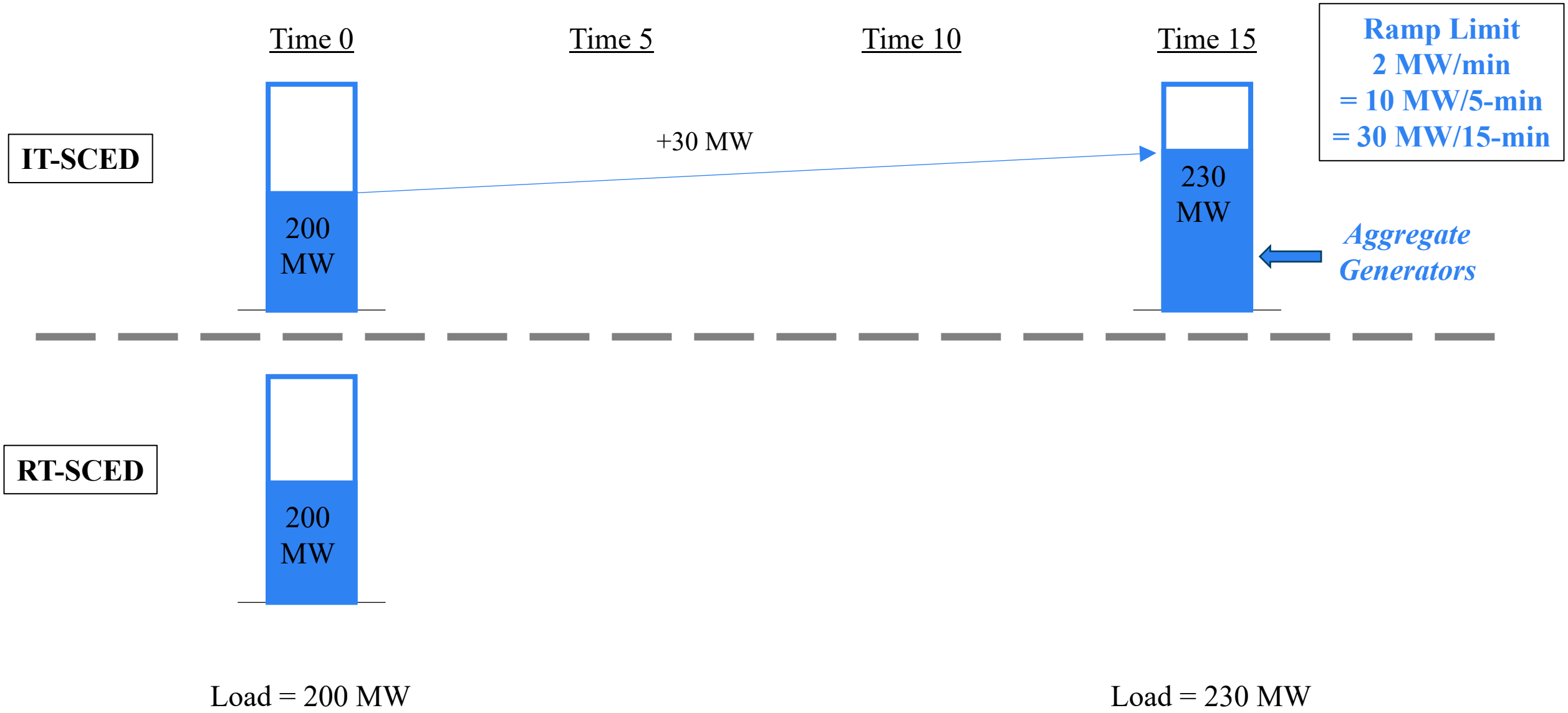
Illustrative Example: IT-SCED vs. RT-SCED



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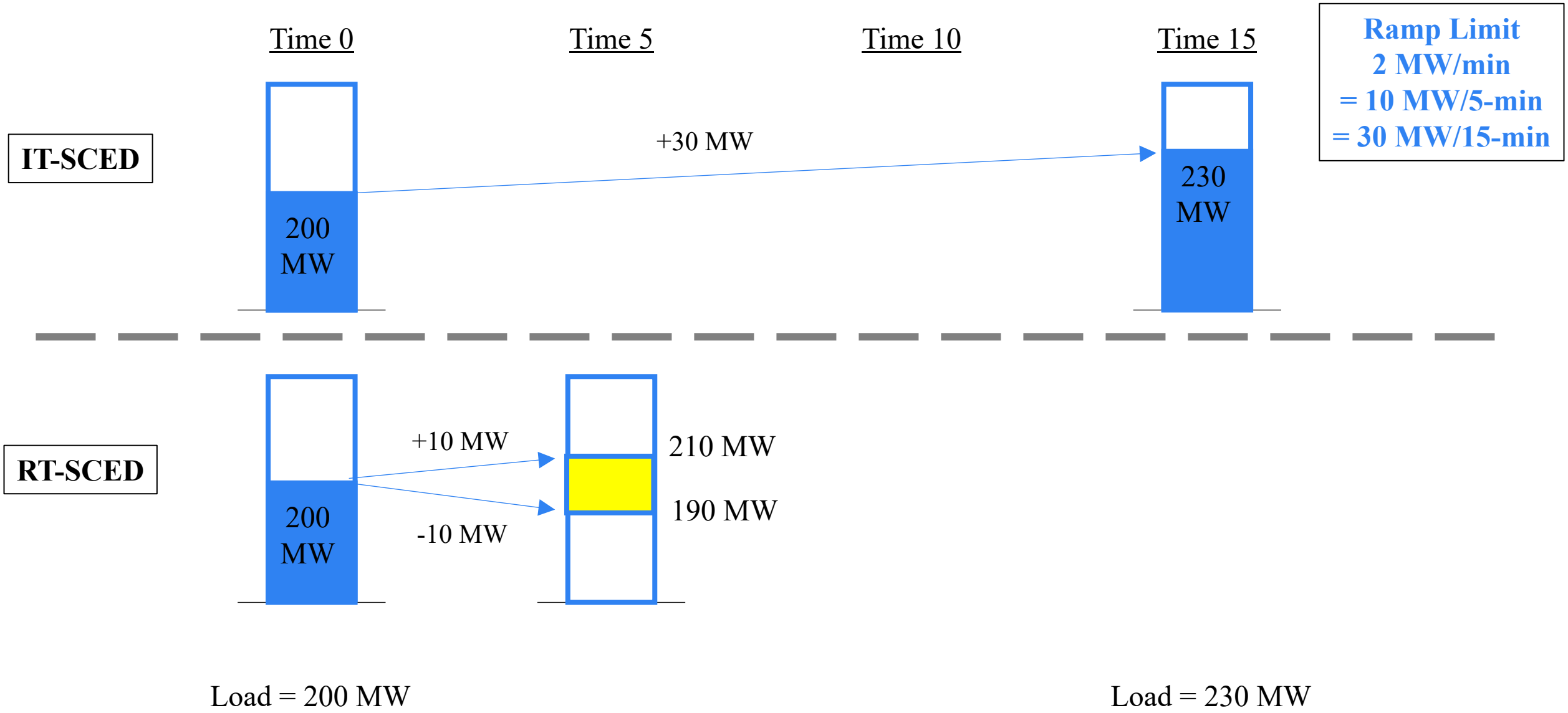

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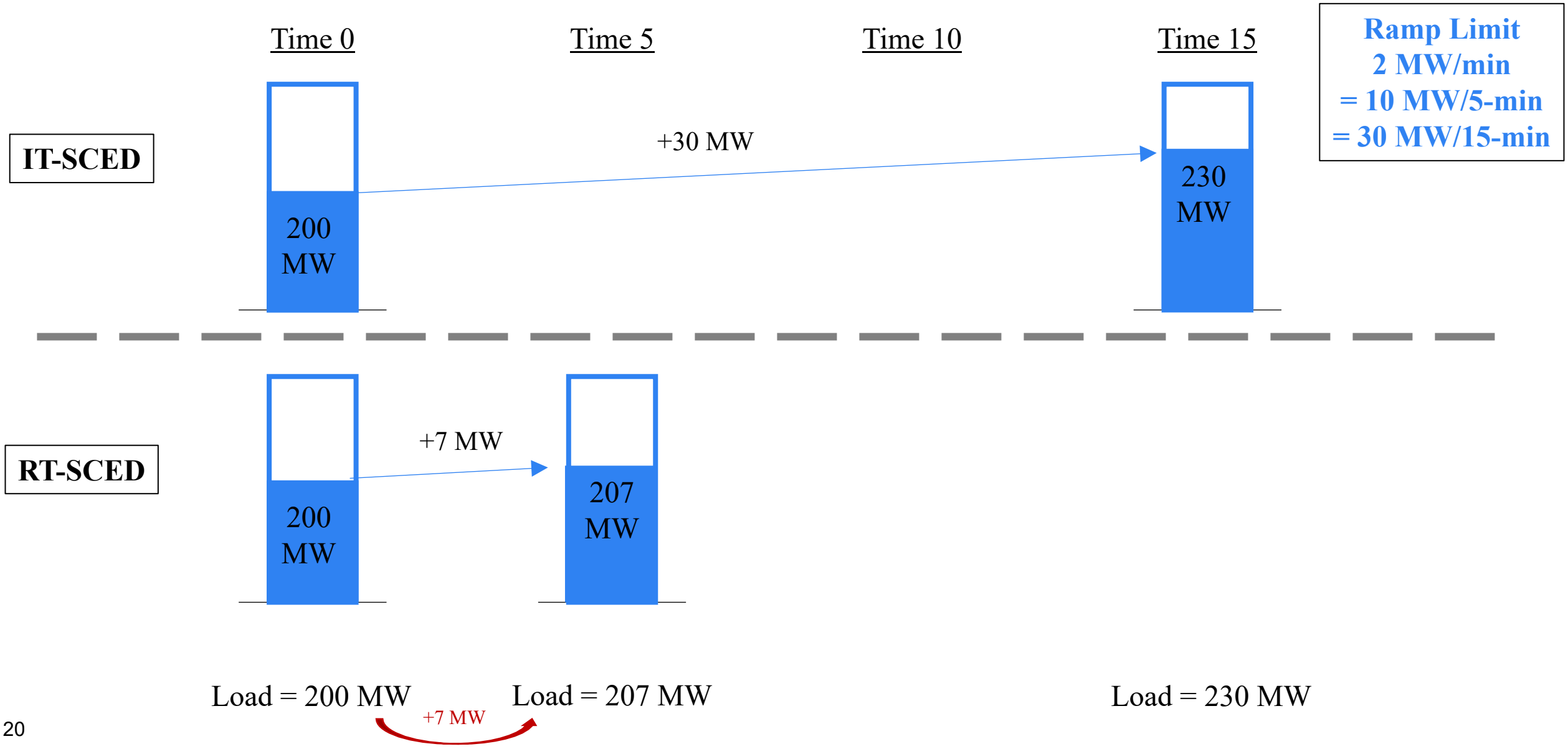

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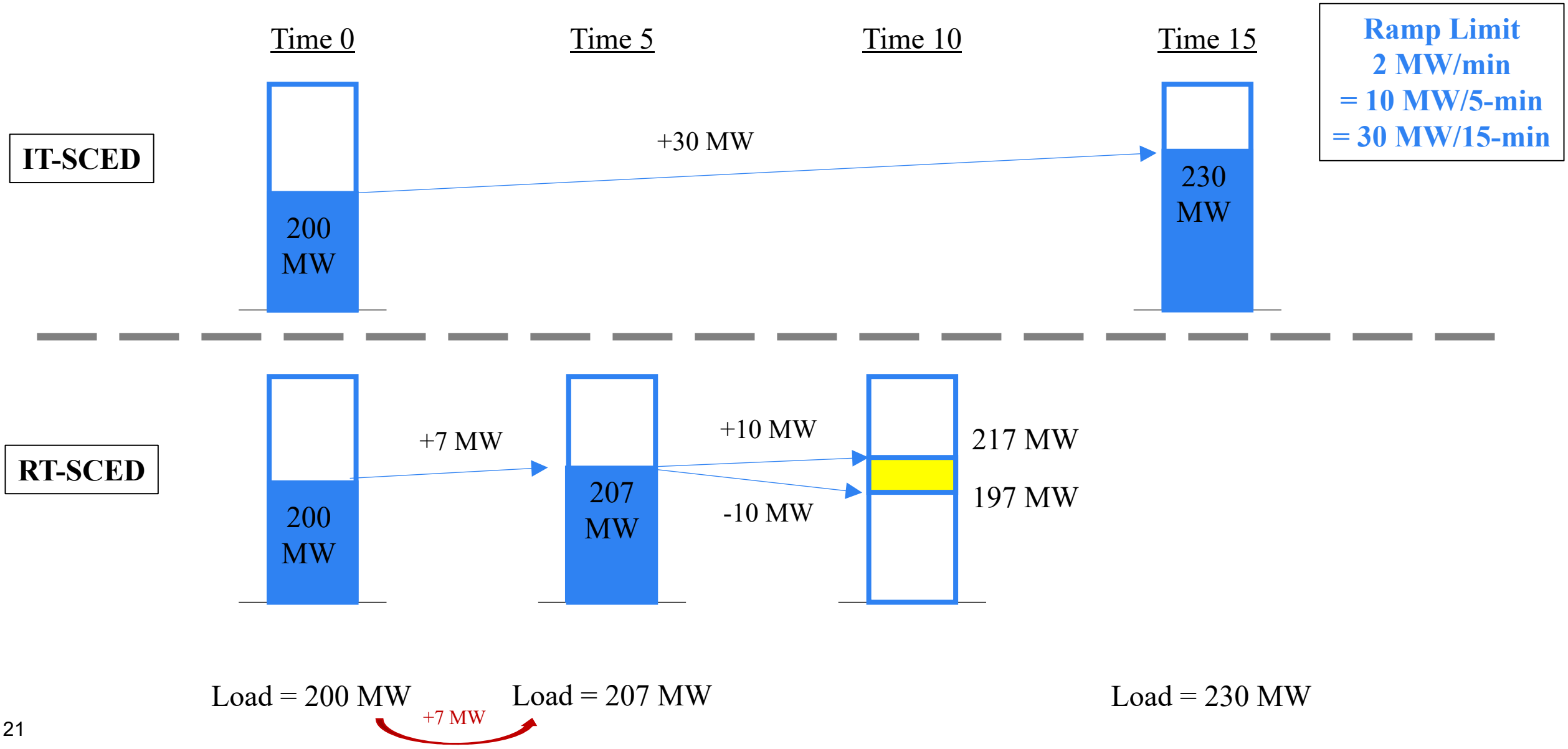

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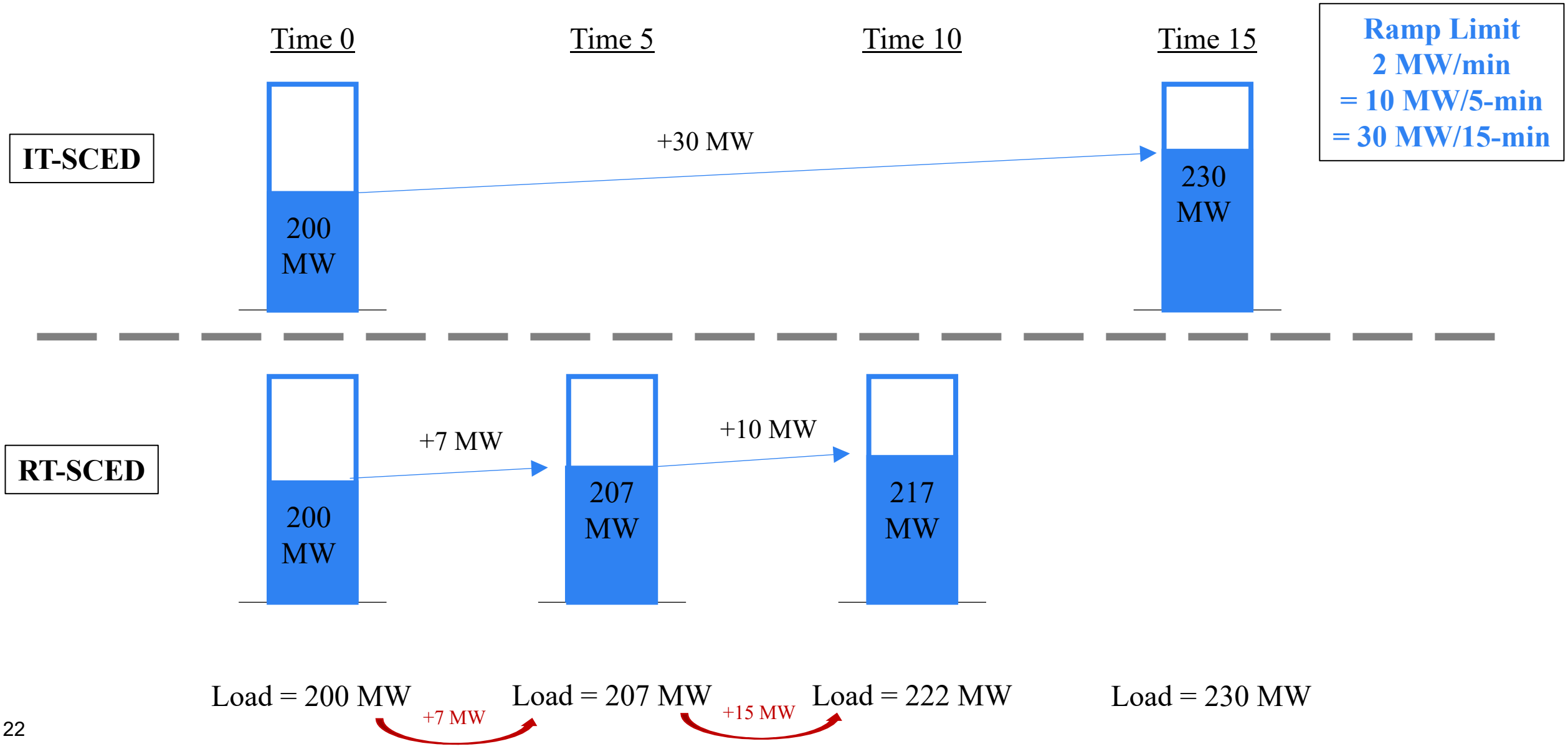

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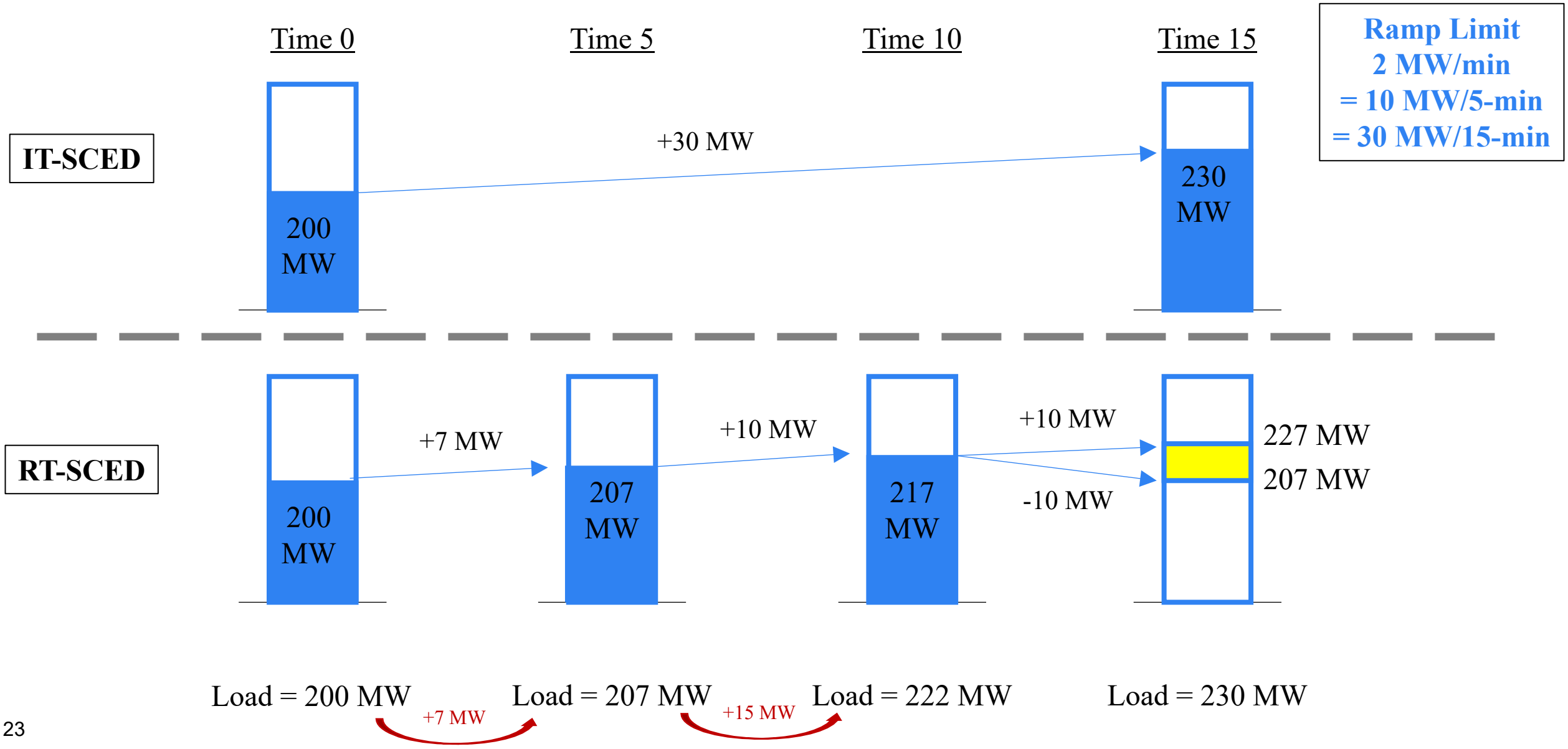

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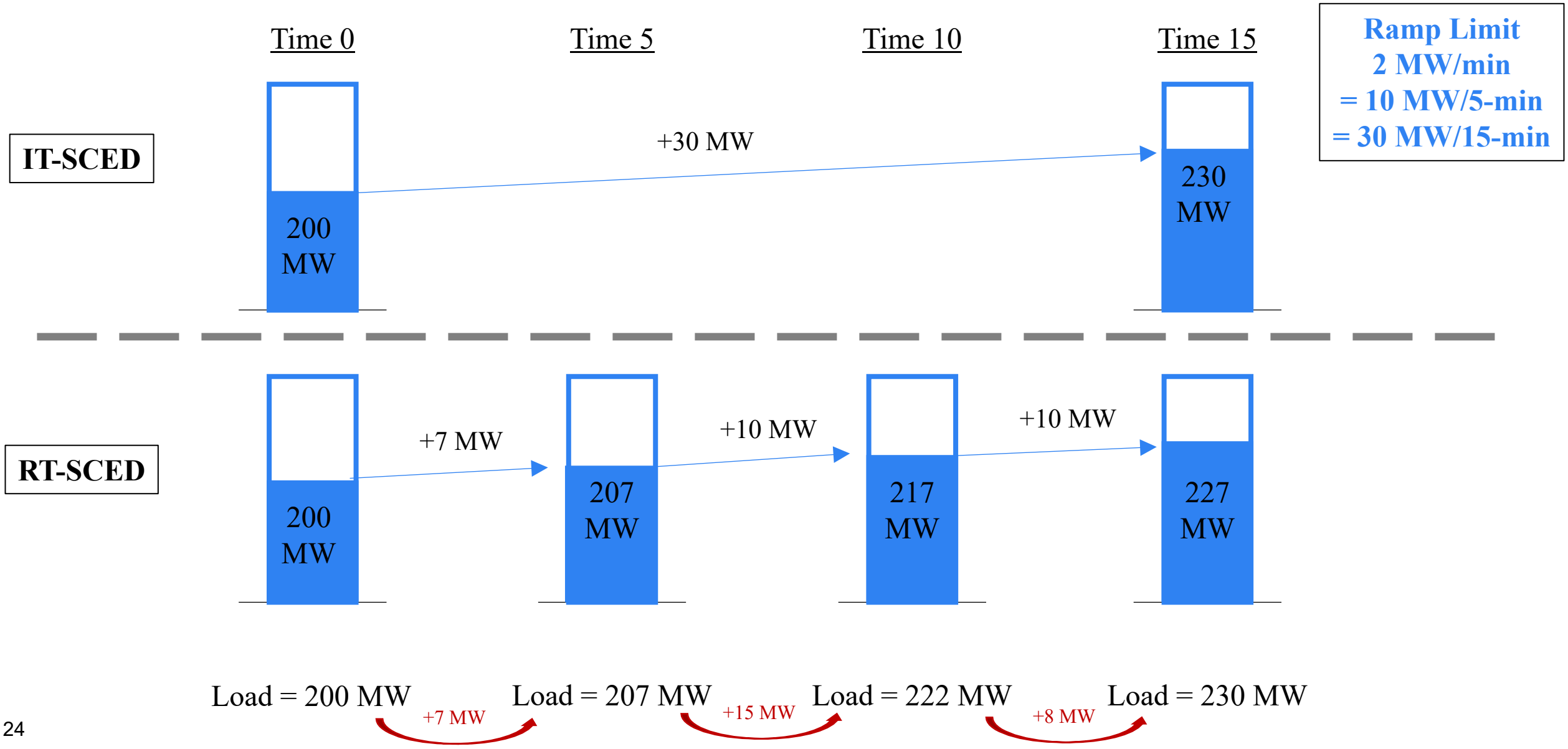

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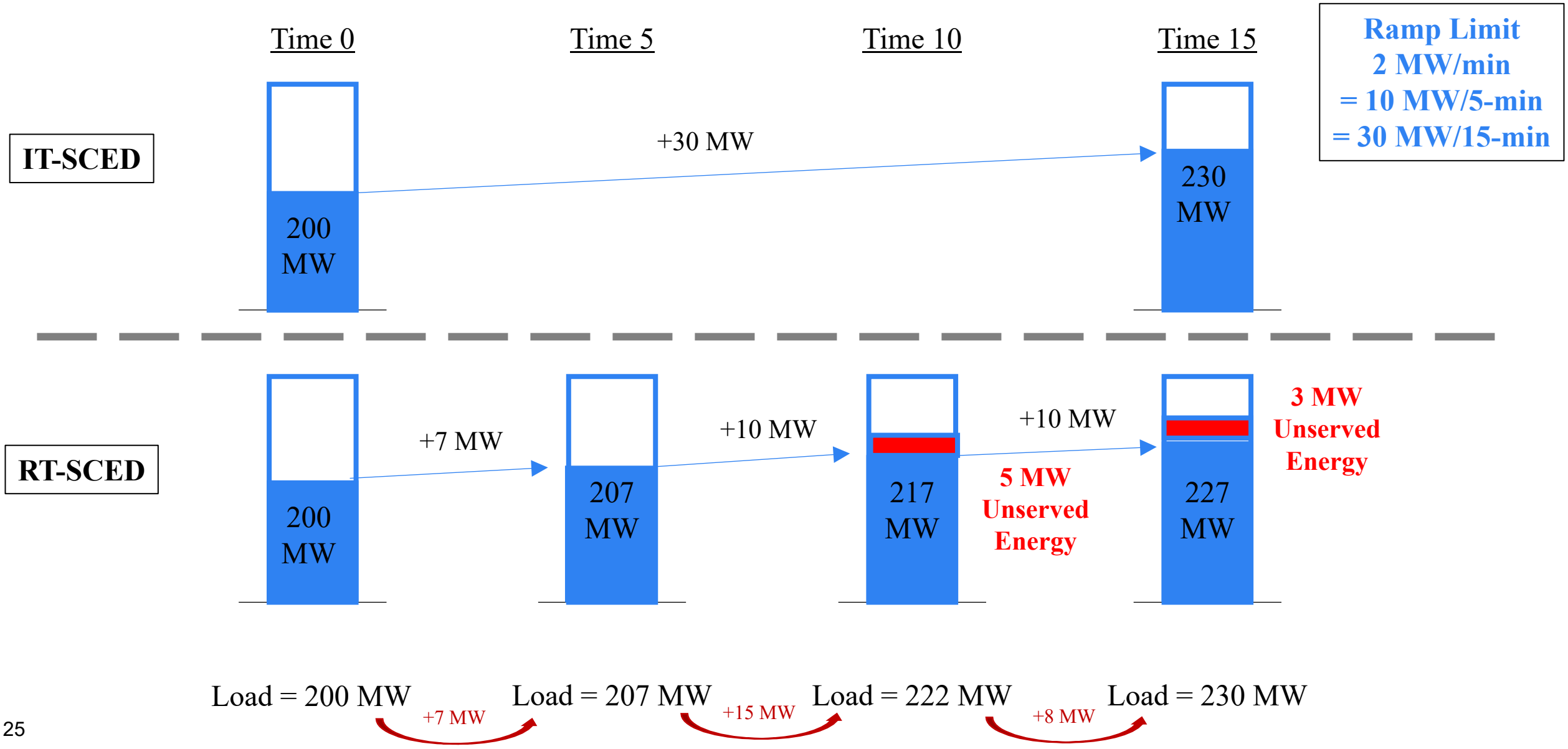

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What is the Objective for any Proposed Solution?

The mix of resources online and their dispatch should:

- Meet load and other reserve requirements in all 5-min. intervals
- Avoid “ramp scarcity” events
- Have sufficient flexibility to:
  - Meet upcoming net load changes beyond the target interval
  - Adjust to any short-term fluctuations in net load
  - Adjust to any forecast uncertainty

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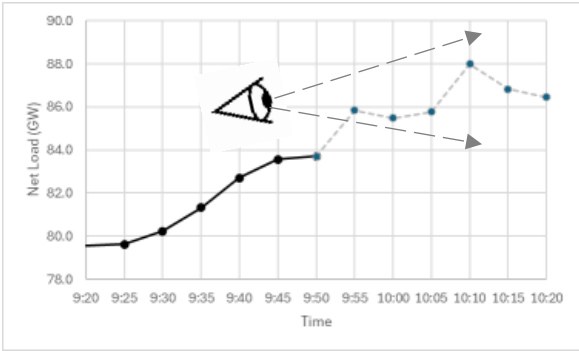
Potential Market Enhancements

- Multi-Interval Economic Dispatch
  - RT-SCED with lookahead window
  - Currently in use in NYISO and CAISO
  - Does not address forecast uncertainty



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  - Addresses uncertainty
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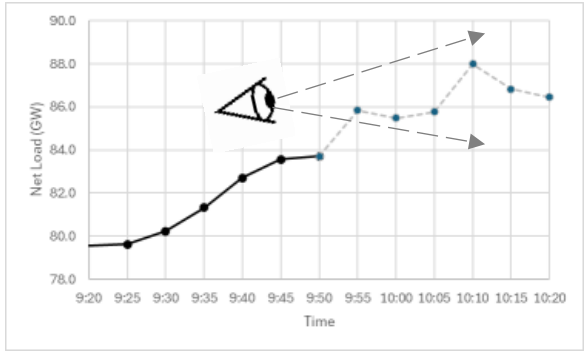

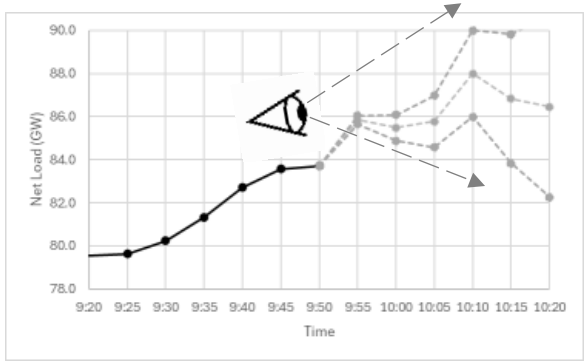

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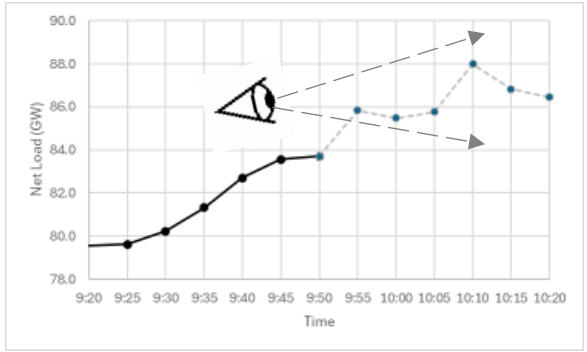
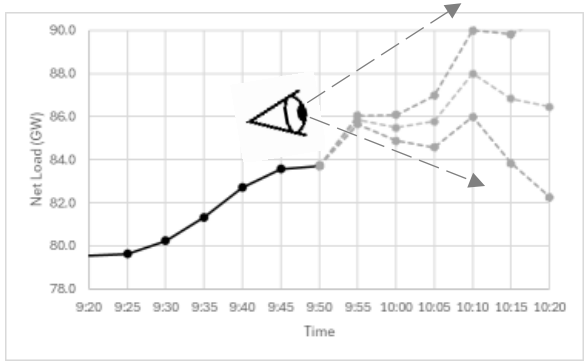
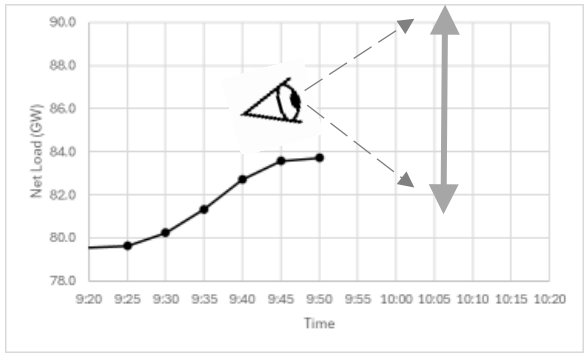
- Flexible Ramping Reserve Product
  - Can be implemented within single interval dispatch







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Today's Focus

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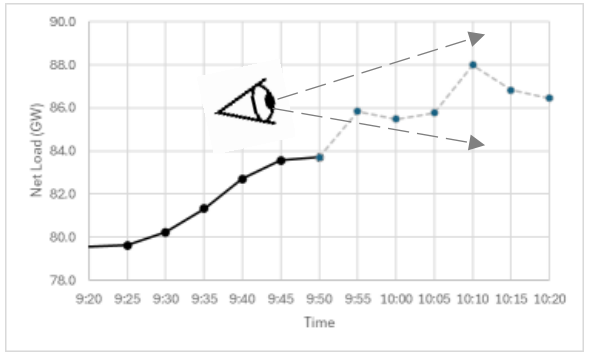

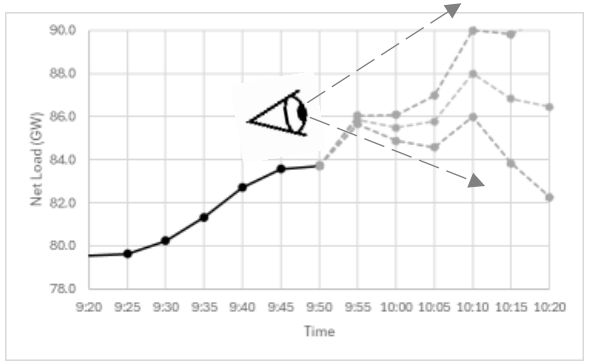

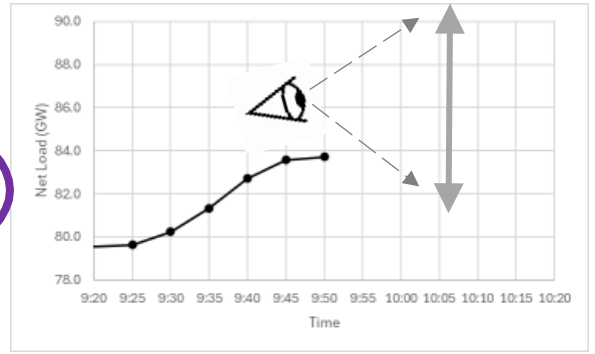

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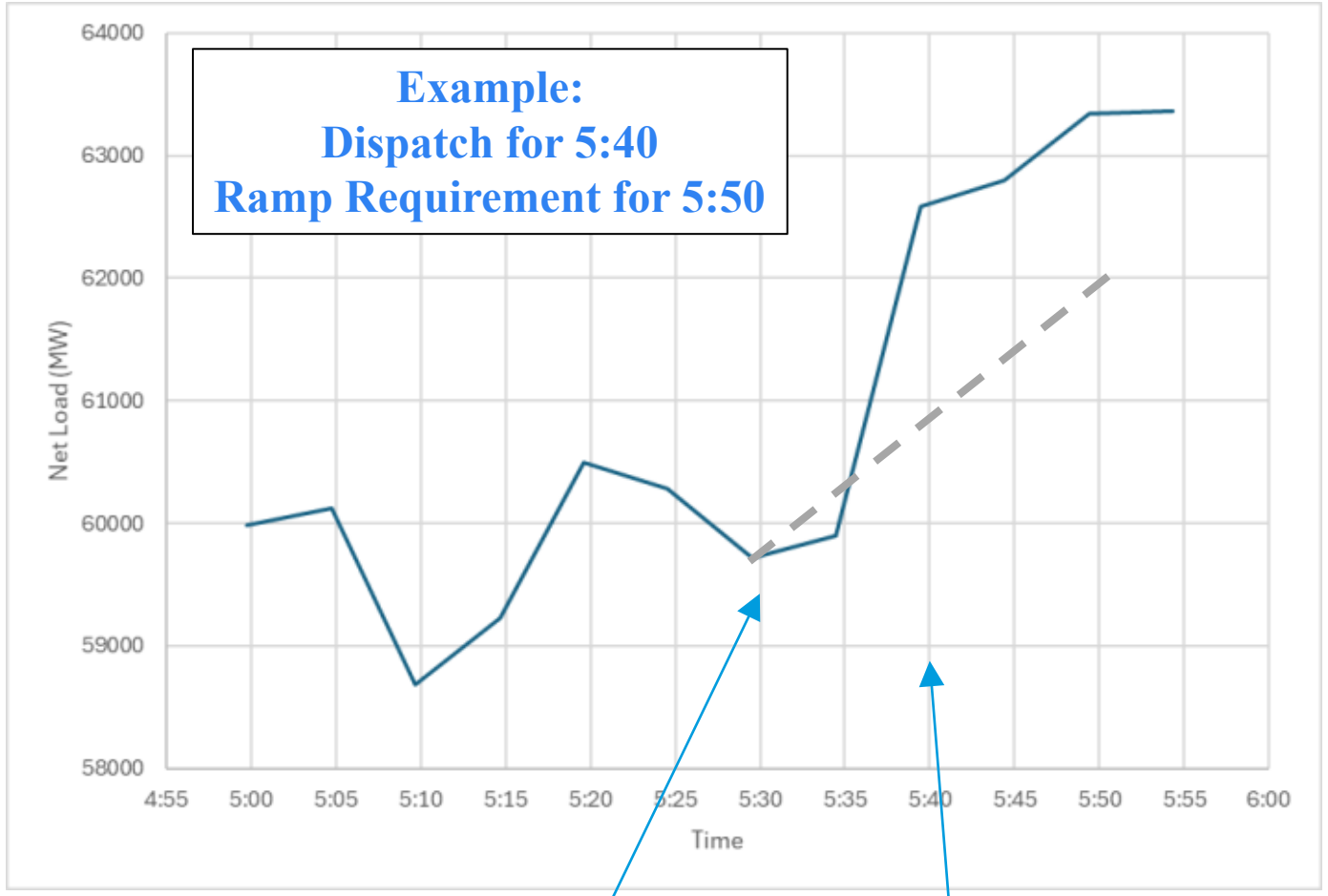
Ramp Product: How does it work?



RT-SCED Execution Time
t - 10

Target Interval
t

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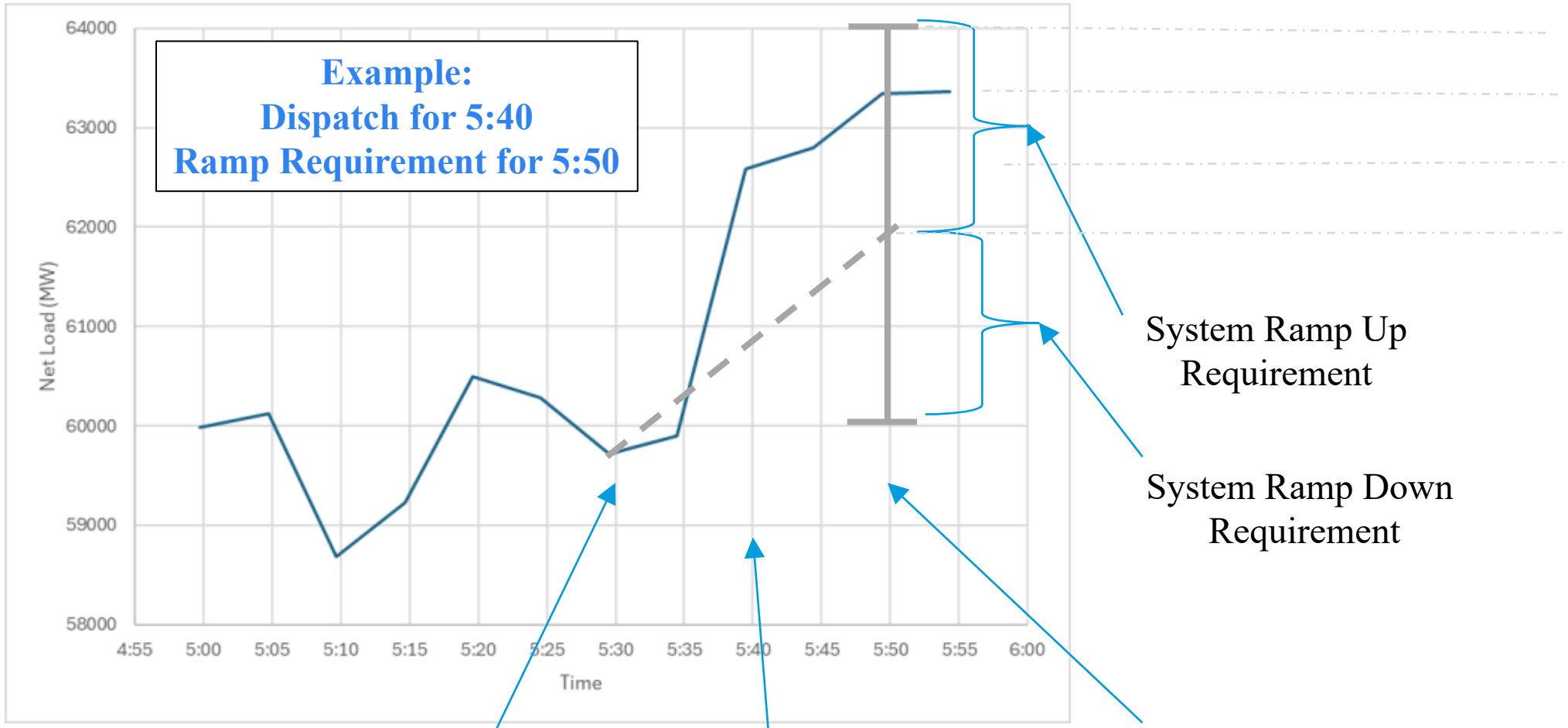

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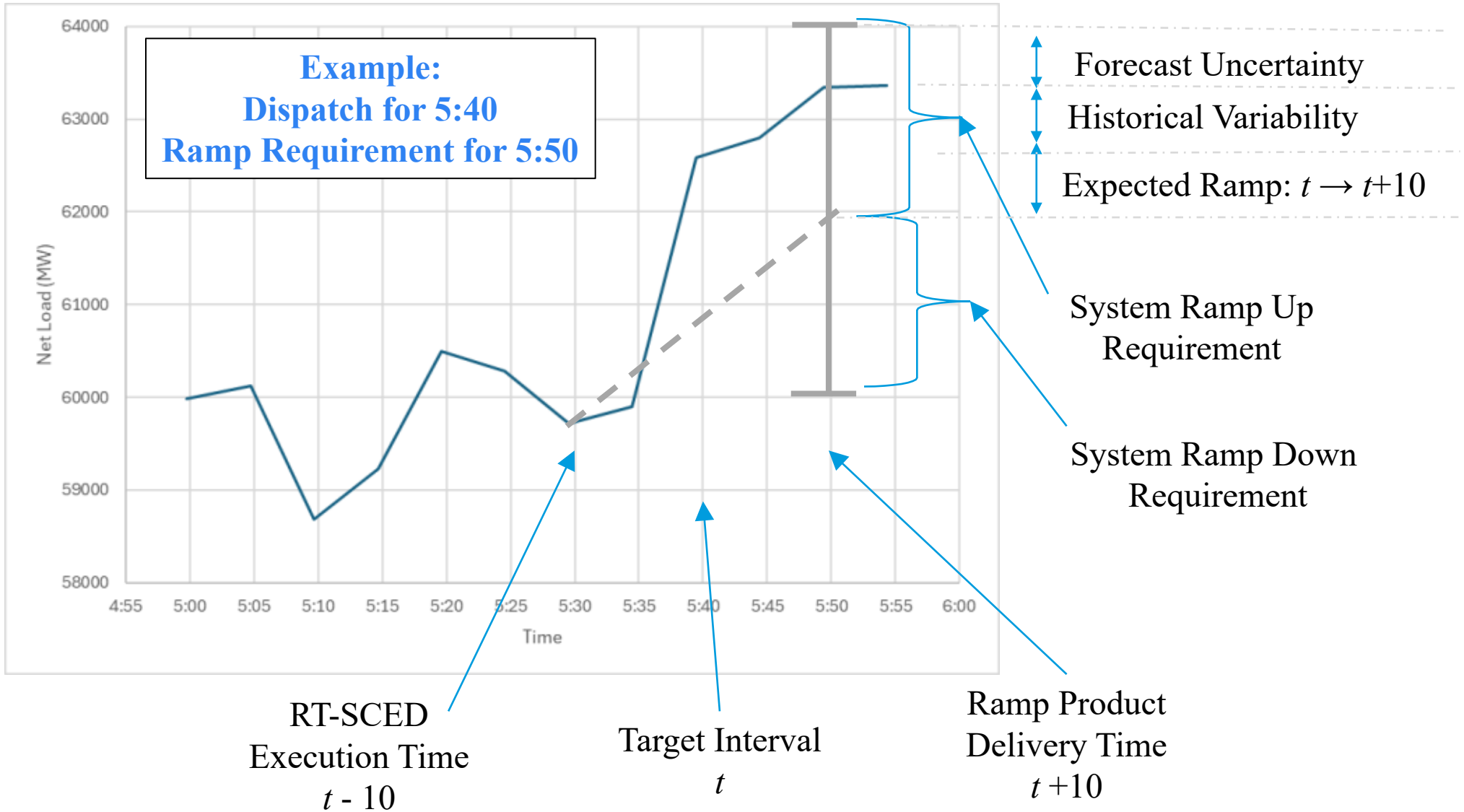

Ramp Products vs. Other Reserves

- Existing Real-Time Reserve Products in PJM
  - 10-minute Synchronized Reserve
  - 10-minute Primary Reserve
  - 30-minute Operating Reserve

- Primary function:
  - Be prepared for ***contingencies*** (e.g., forced outage events)
  - Necessary to meet NERC reliability standards

- Not intended as additional ramp for “normal” net load fluctuations

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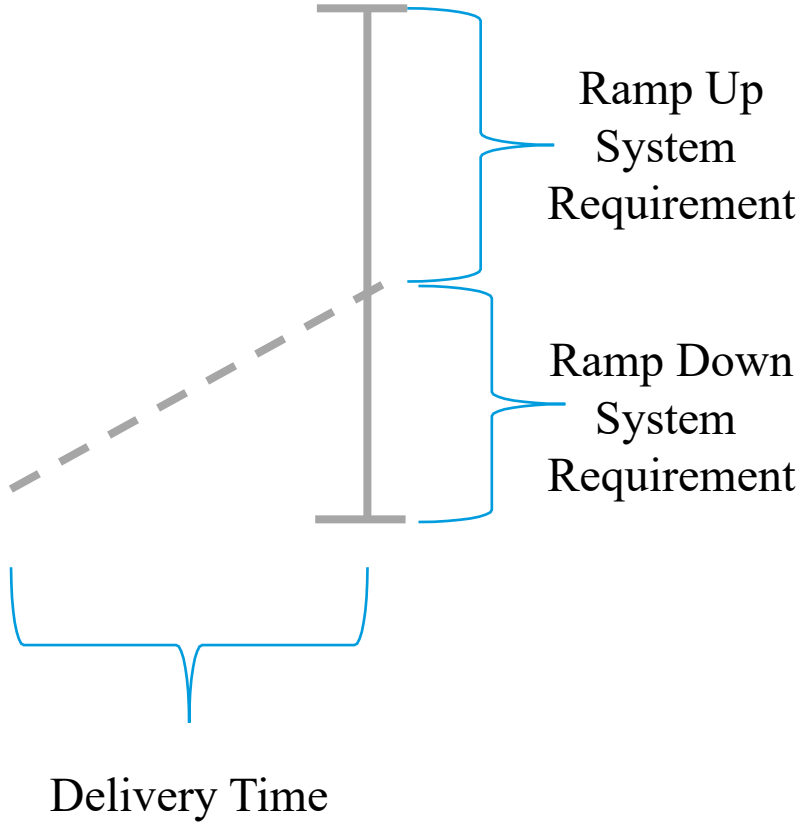
Ramp Product: Design Choices

- Delivery time?
- Quantity to Procure Up & Down?
  - How to determine system requirements?
- Prices in Demand Curve?
  - e.g., penalties for shortage
- Cascade with other Reserve Products?
- Include non-spinning contributions?
  - (for longer delivery times)
- Which resources are eligible to provide?



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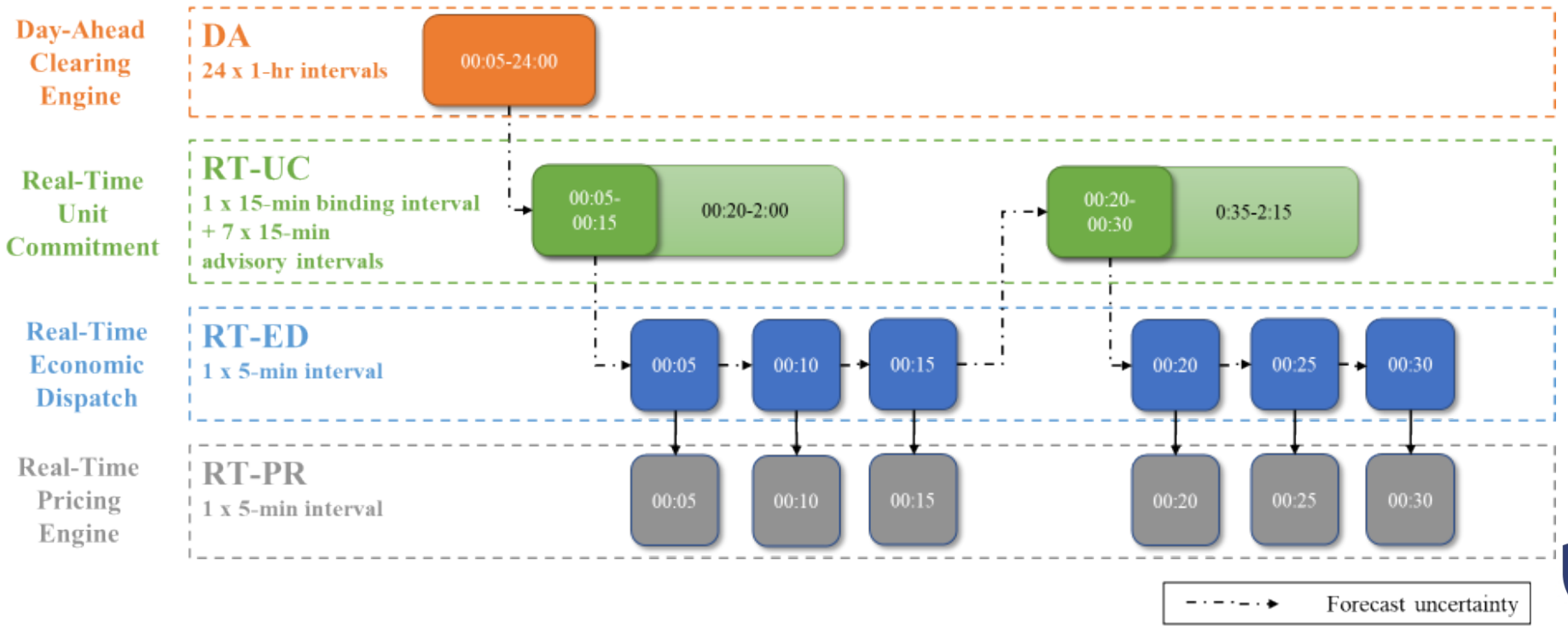
PJM Market Simulation Model: Rolling Horizon

- Developed by PSU-PJM team since 2020 (U.S. Dept. of Energy)
- Simulates the rolling horizon and uncertainty in real-time forecasts
  - Most models optimize over the entire day, assume net load is known
- Can simulate a full year at 5-minute time-scale



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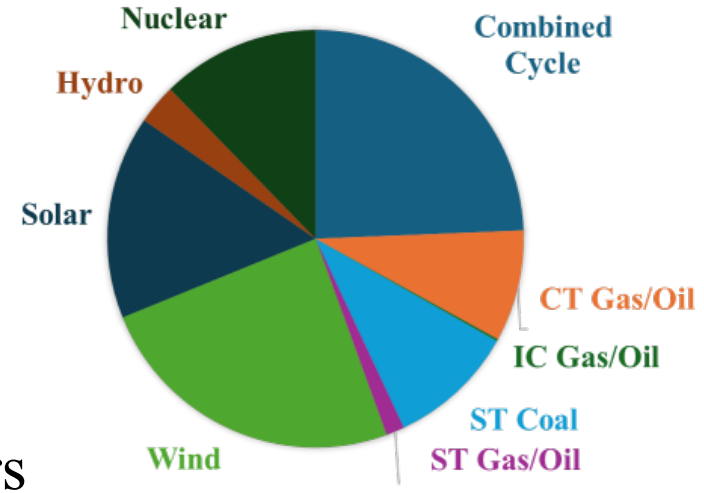
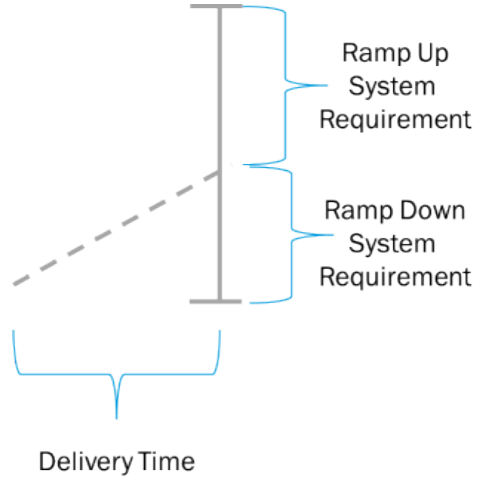
Simulation Assumptions

- Future PJM resource mix (hypothetical)
  - Accelerated thermal unit retirements
  - Additional wind, solar installed capacity
  - Load growth
  - Increase in day-ahead and real-time forecast errors
- Simulated Ramp Product (example)
  - 10-minute delivery time
  - Procures expected ramp plus uncertainty
  - Not cascaded with other reserves
  - Lower penalty for shortage than other products





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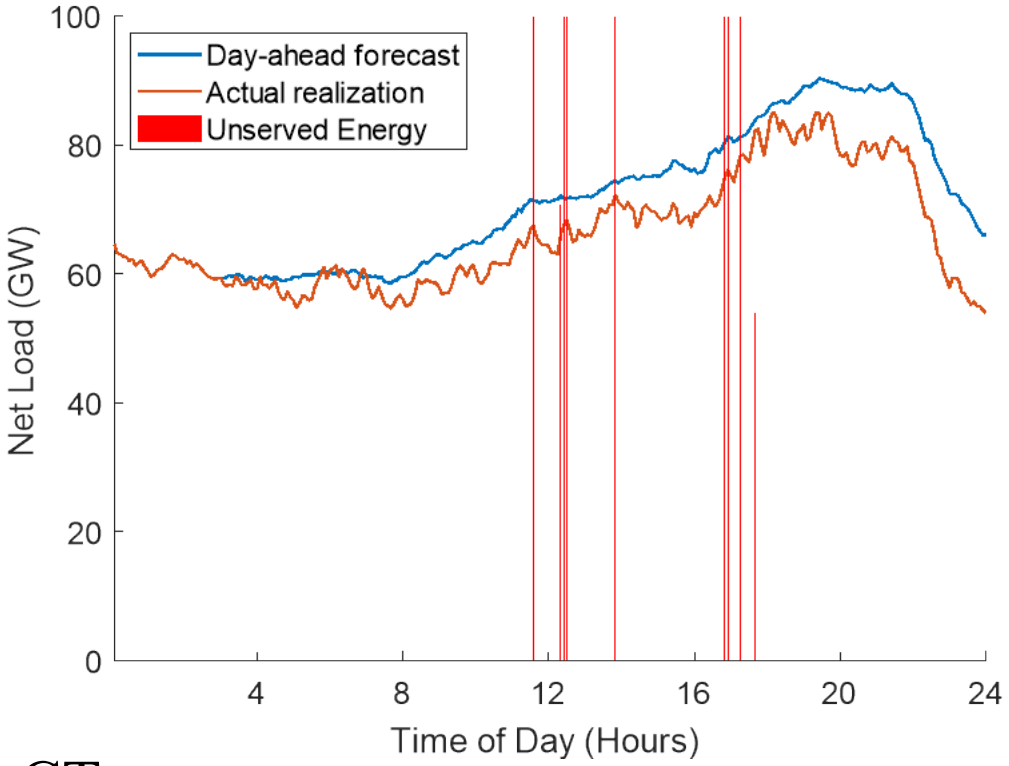
Example: One Day in Late Spring

- DA over-forecast
- Net load volatility in real-time
- "Unserved Energy"
  - Shortfall from market-cleared supply
  - Indicator of system stress
  - Requires additional processes
- Including a 10-min. Ramp Product
  - Eliminates all "unserved energy"
- How does ramp improve reliability?
  - More capacity brought online in RT
  - Ramp capability provided by mix of CC & CT
  - Some units pre-ramped to be prepared



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Discussion: General Trends and Questions

- Majority of simulated days for a future case
  - Adding a ramp product alleviates system stress and improves reliability
  - Primary mechanism: inducing additional commitments in real-time
- Cost impacts
  - Main effect: shifts out-of-market costs into the real-time market
- How much ramp to procure?
  - Large requirement increases cost; Lower requirements may be ineffective
- Delivery time?
  - Short-term (e.g., 10-minutes)?
  - Long-term (e.g., 60-minutes)?
  - Multiple products?

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Thank you

Contact:

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Professor of Energy Engineering
Dept. of Energy and Mineral Engineering
Pennsylvania State University

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Ramp Products in Other Markets

Ramp Reserve Products in ISO/RTOs

	MISO	CAISO	SPP
Short-Term Ramp Products			
Product Name	Up and down Ramp Capability	Flexible Ramping Product- upward and downward reserves	Ramp Capability Product
Time Requirement	10 mins	5 mins	10 mins
Long-Term Ramp Products			
Product Name	Short-Term Reserves	Imbalance Reserves	Uncertainty Product
Time Requirement	30 mins	15 min, but focused on day-ahead	One Hour

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