Flexibility Procurement and Reimbursement

A Multi-period Pricing Approach

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ANALYST

Outline

- Introduction
- Motivation: Real-time (RT) market shortcomings
  - Problems with current methods
- A recent improvement
  - Ramp product design
  - Identified issues
- Multi-period pricing proposal
  - Design
  - Advantages and disadvantages
- Conclusion

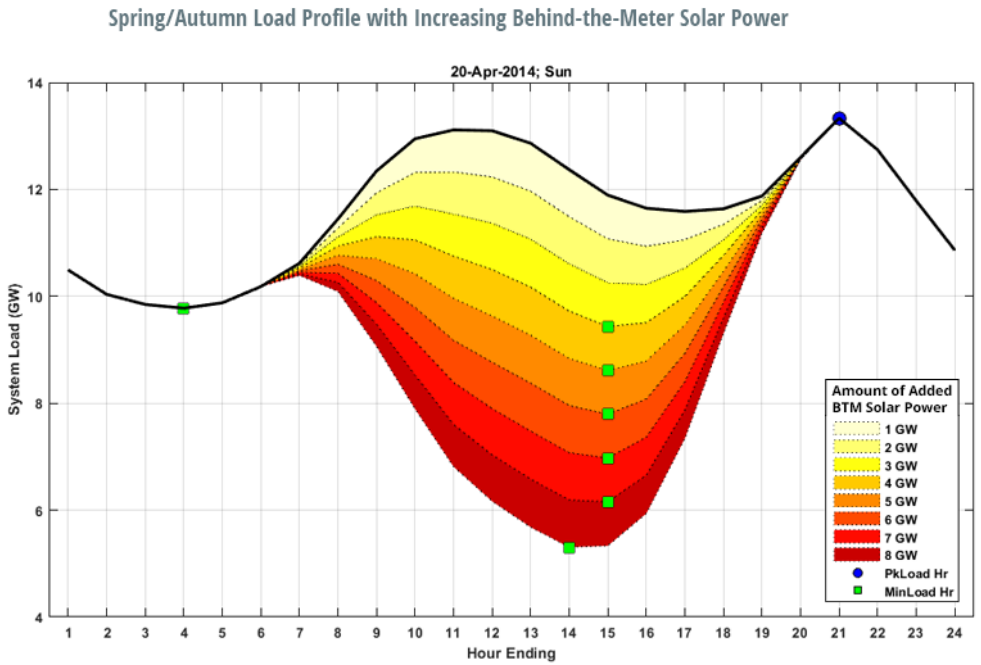
INTRODUCTION

Flexibility needs for RT processes

- Flexibility: Capability to cope with system condition changes over time
- Why is flexibility needed?
  - Expected load changes
  - Load changes caused by uncertainty (e.g., distributed generation)

Flexibility needs for RT processes

- Flexibility needs will likely increase with distributed renewable energy penetration
  - Steeper and longer ramps



Flexibility needs for RT processes

- Current flexibility procurement and reimbursement methods take a piecemeal approach that may not be satisfactory as system characteristics change

MOTIVATION: RT MARKET SHORTCOMINGS

Motivation

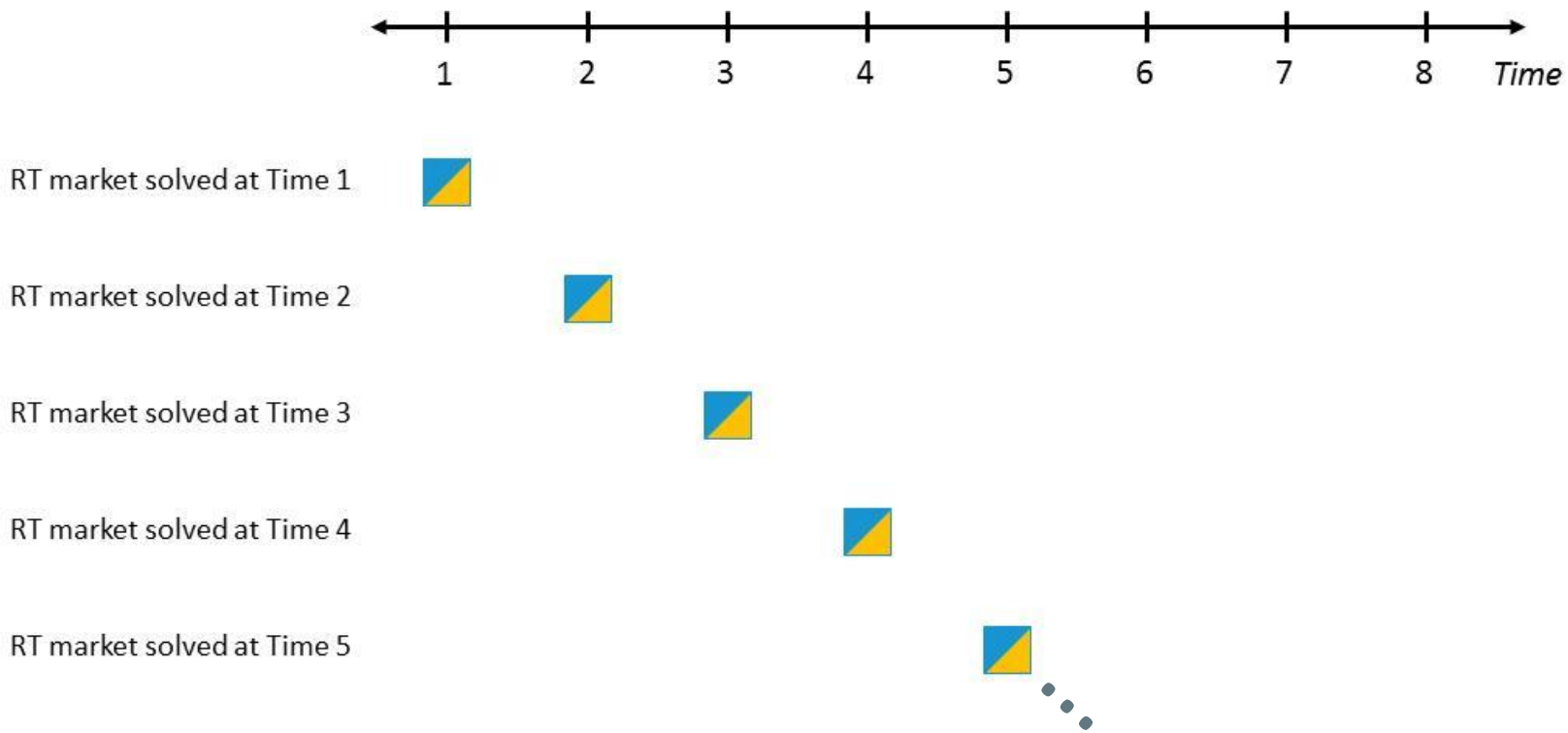
- Dispatch should follow load and maintain reliability, both objectives dependent on flexibility
- Current RT market designs have problems with
  - **Dispatch efficiency**
    Does the RT market maximize social surplus over the time?
    Is the RT dispatch reliable?
  - **Compensation**
    Does the RT settlement incentivize units to perform as requested?
    Does the RT settlement ensure cost recovery?

LEGEND

Look-ahead period, price USED for settlement

Single-period pricing

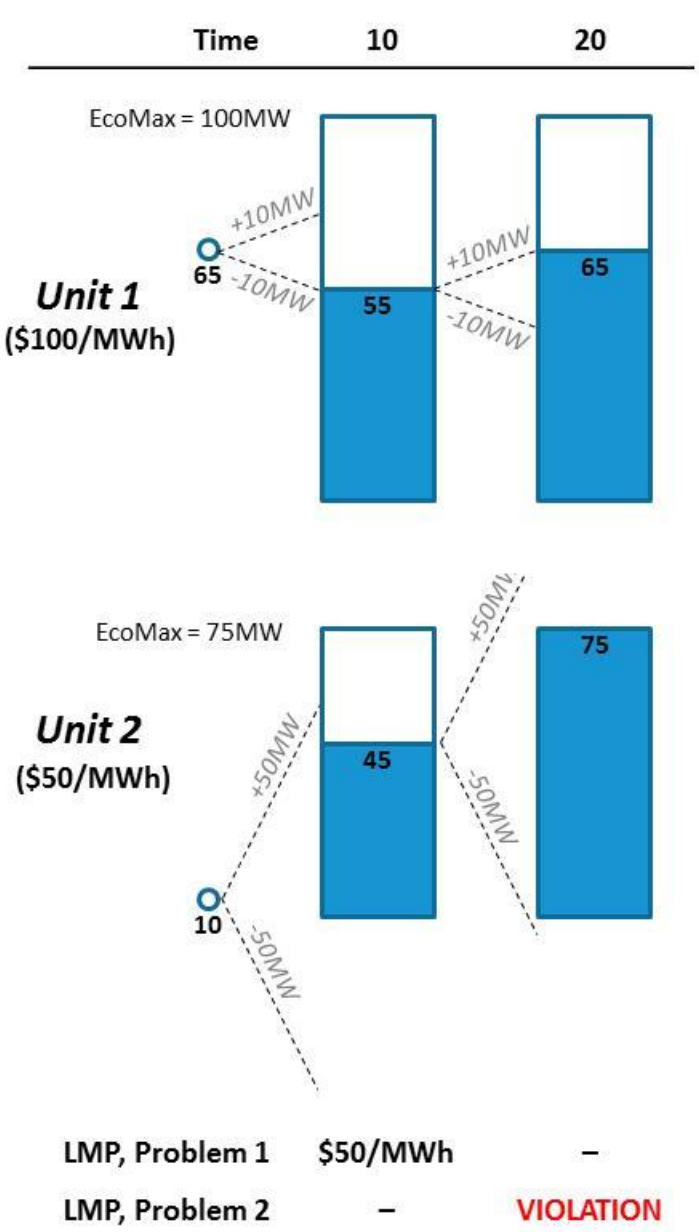
- Each Dispatch problem solves for one time
- Price is used for settlement



Single-period pricing

- ISO New England, MISO, PJM, and SPP
- Advantage
  - Easy to implement and understand
- Disadvantage
  - Actions must be taken to avoid solutions that cause future infeasibility
    - If actions fail, reliability can be compromised → Inefficient
    - If actions succeed, they are almost always suboptimal → Inefficient
- The **Dispatch efficiency** problem is illustrated next

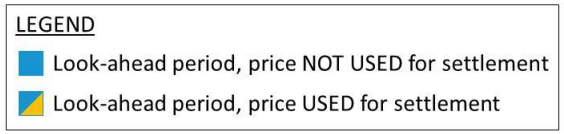
Time	Load
10	100
20	155



Legend

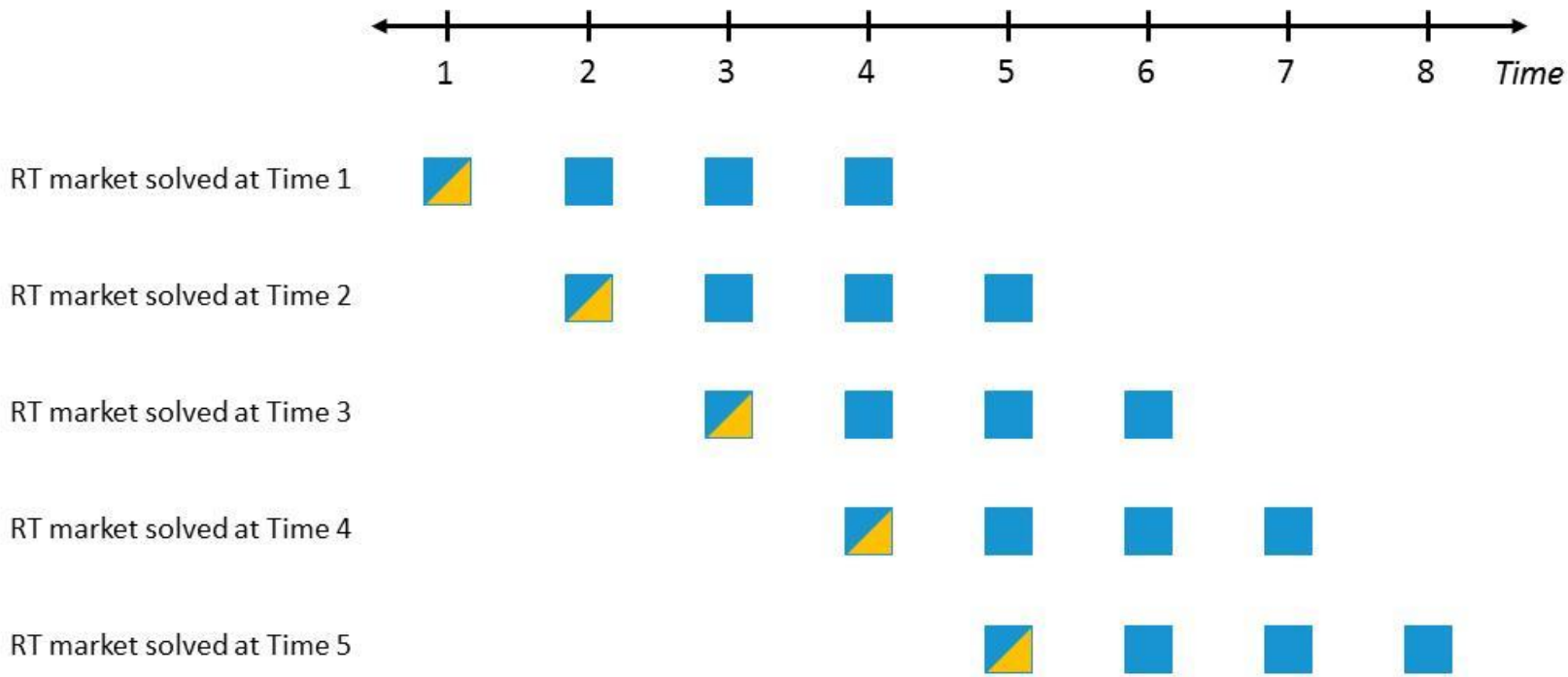
Power

- If the future isn't considered, Unit 1 output is decreased as quickly as possible for Time 10
- It is then impossible to satisfy Time 20 load!
- The dispatch is inefficient



Single-period pricing with multiple look-ahead periods

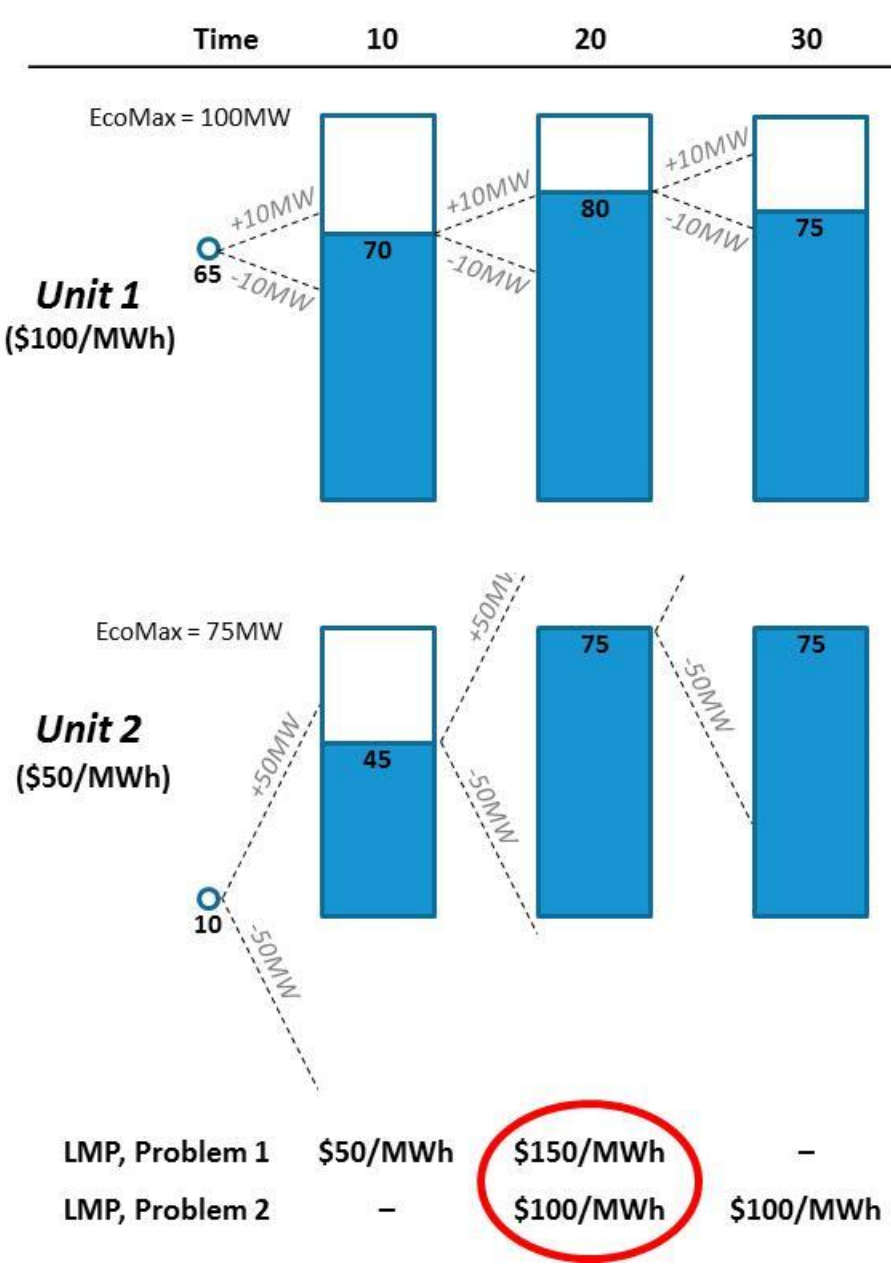
- Each Dispatch problem solves for multiple times
- Only first price is used for settlement (i.e., binding)



Single-period pricing with multiple look-ahead periods

- CAISO and NYISO
- Advantage
  - If the horizon is longer than the required ramp, the dispatch is efficient
- Problem
  - Binding peak price can be systematically lower than advisory peak price (opposite for off-peak price)
  - Compensation may not be adequate → Deviation incentive
- The **Compensation** issue is illustrated next

Time	Load
10	100
20	155
30	150



- Problem 1 solution dispatches Unit 1 up to maintain Time 20 feasibility
- The advisory peak price is $150/MWh but the realized price is only $100/MWh
- More realistic situations can result in the same behavior

Summary

- **Dispatch efficiency** and **Compensation** problems mean that flexibility is not adequately procured or reimbursed by traditional dispatch
- These problems may become more important as the system continues to evolve
- Is there a better way to provide flexibility?

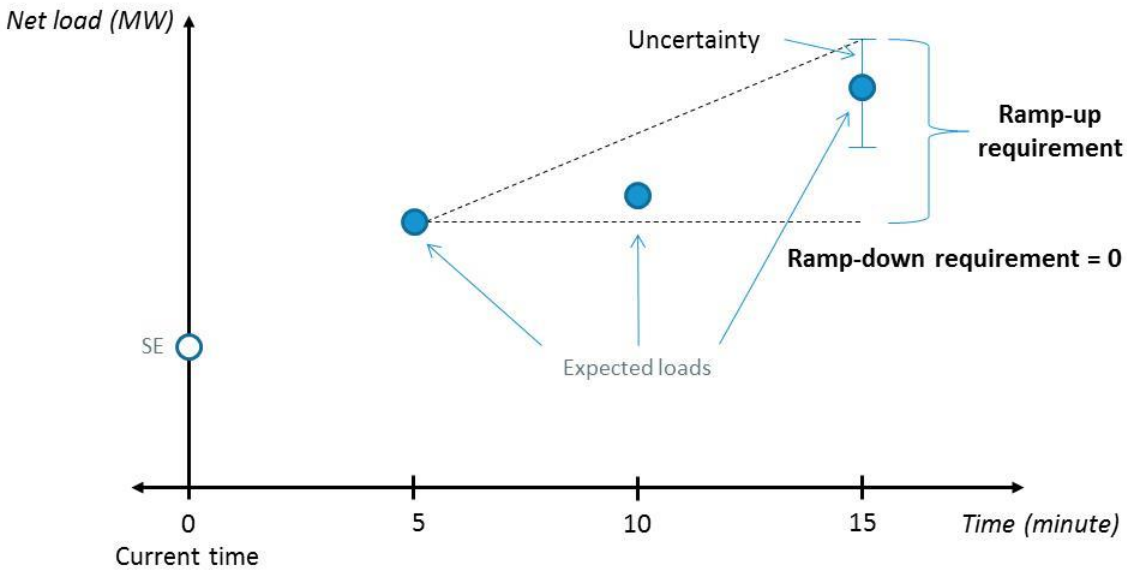
A RECENT IMPROVEMENT

Ramp products

- MISO and CAISO introduced “ramp products” to enhance and reimburse for flexibility
  - Up-ramp and down-ramp
  - Market clearing prices

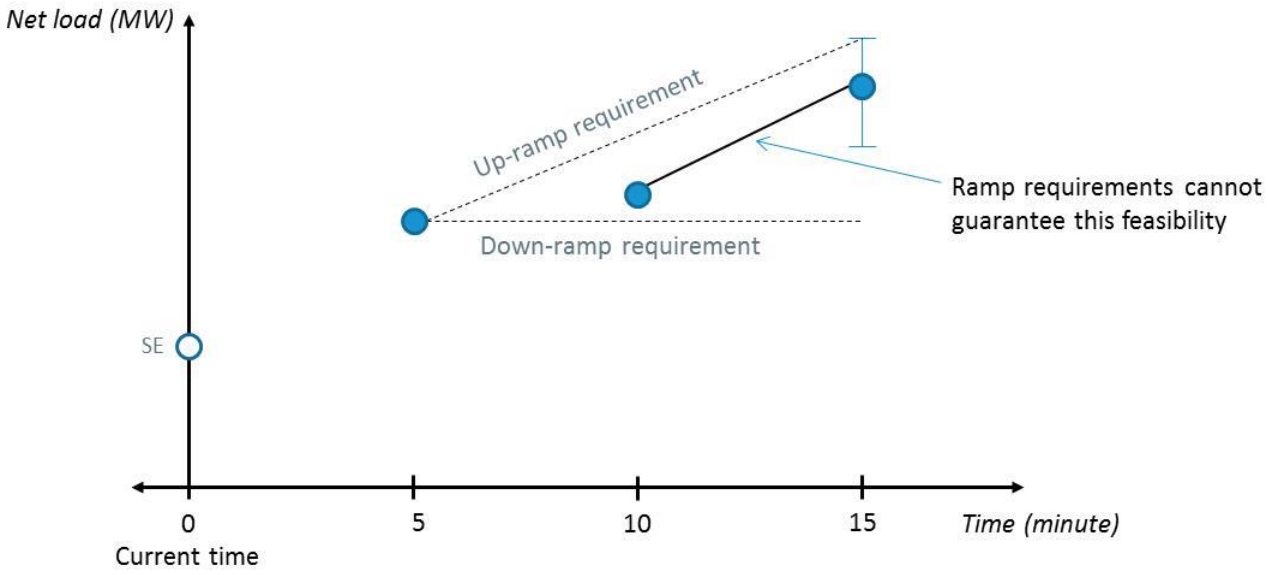
Ramp products (MISO design)

- Up-ramp and down-ramp requirements are based on expected load change + uncertainty



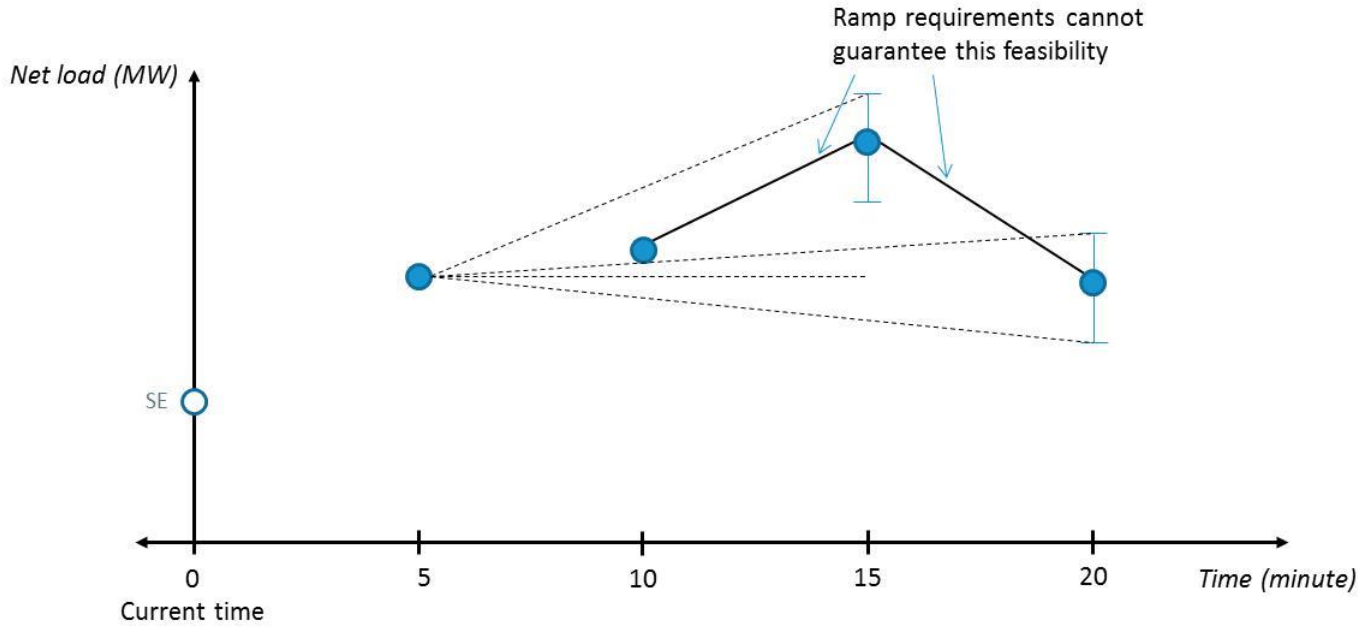
Ramp products may not maintain reliability

- Ramp products can only provide flexibility between the dispatch time and the specified target time



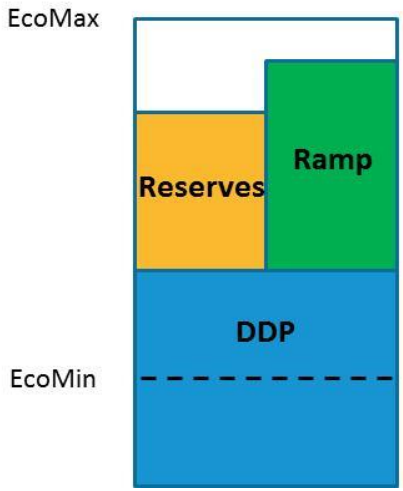
Ramp products may not maintain reliability

- If longer-term flexibility becomes a problem, additional ramp products may not help



Ramp products are not well-defined

- 10-minute reserves represent ramping capability 10 minutes after the dispatch time
- Reserve designations and up-ramp products naturally overlap



- The ISO can't double-pay for capability

What are the true ramp product designation and requirement definitions?

Ramp products. Conclusion

- Poorly defined
  - Ramp products and reserves
- Does not guarantee reliability

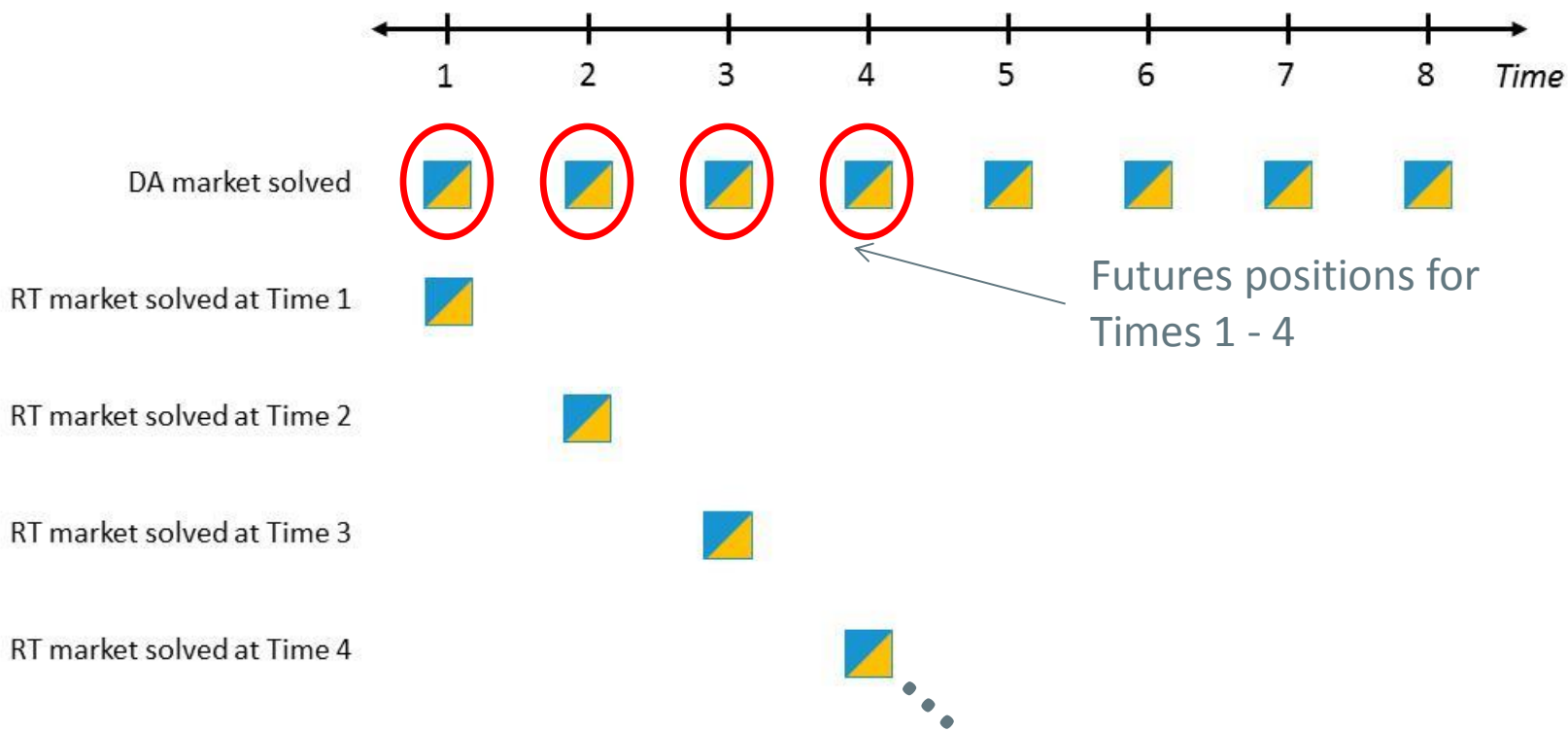
MULTI-PERIOD PRICING PROPOSAL

LEGEND

Look-ahead period, price USED for settlement

Multi-period pricing

- ISO New England's DA-RT market is a two-settlement design
  - The cleared DA quantities are [cash-settled] futures positions

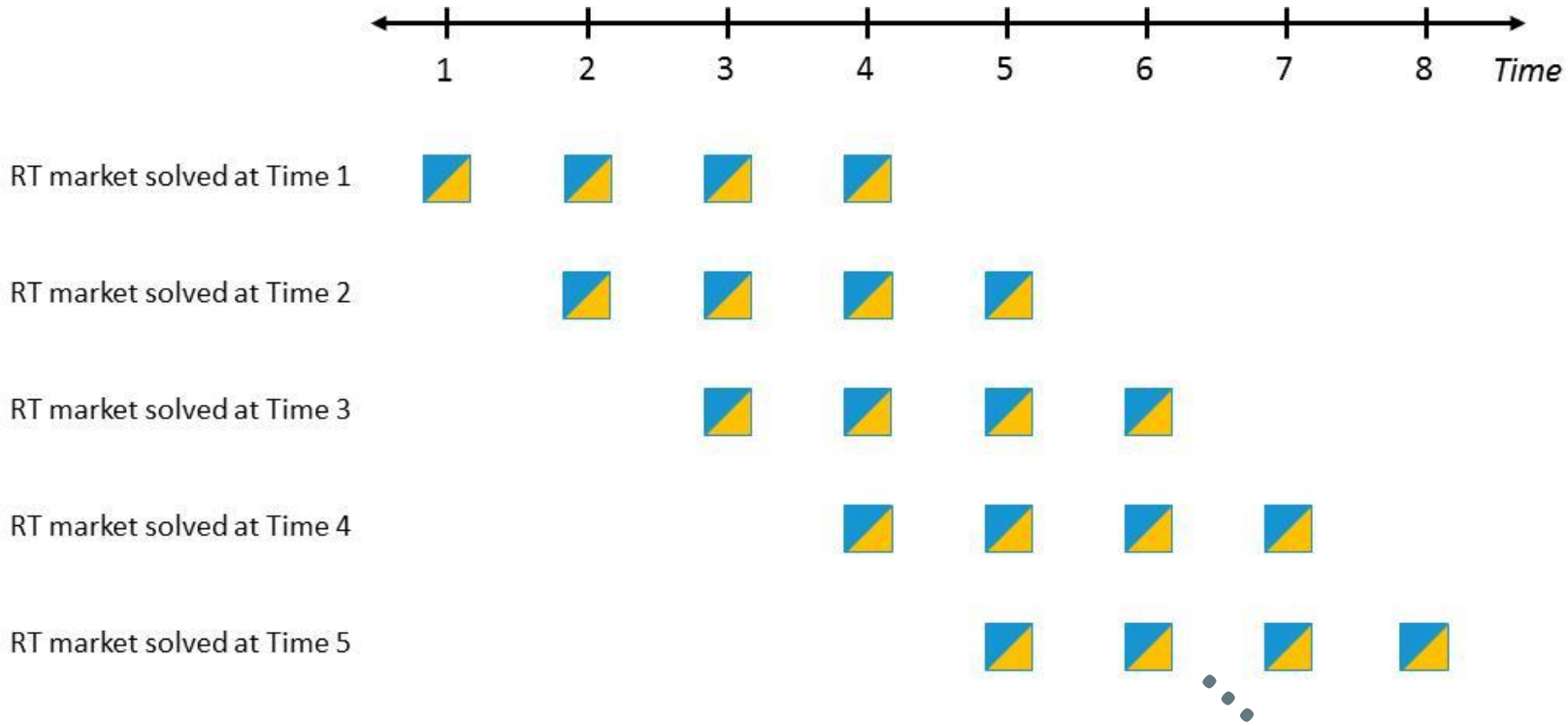


LEGEND

Look-ahead period, price USED for settlement

Multi-period pricing

- Consider extending this framework to the RT market itself
  - RT market must be multi-period
  - This treatment expands on the CAISO and NYISO approach

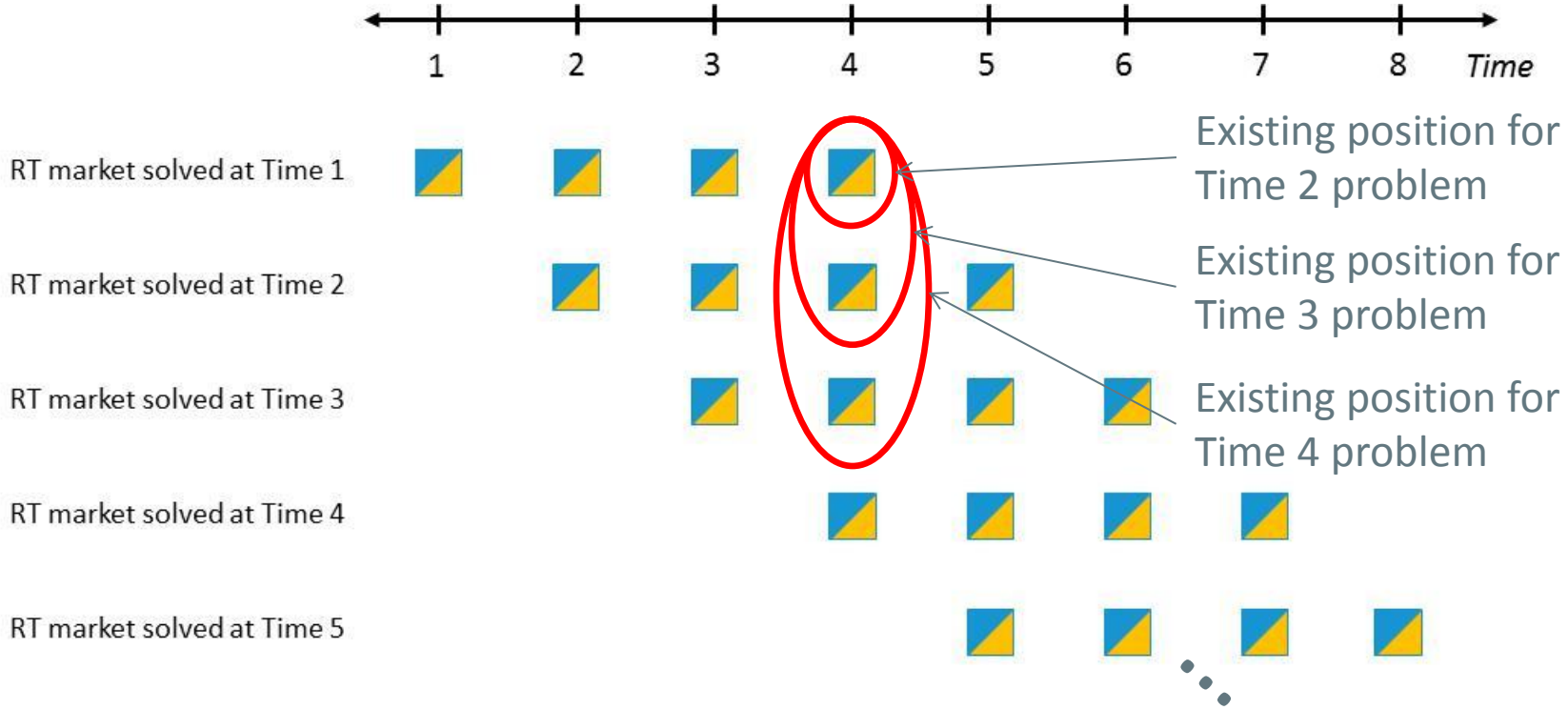


LEGEND

Look-ahead period, price USED for settlement

Multi-period pricing

- Deviations from net existing positions are new positions
  - Existing positions for Time 4 are shown below
  - Time 4 is new in the Time 1 problem → No existing position



***Multi-period pricing*. Settlement**

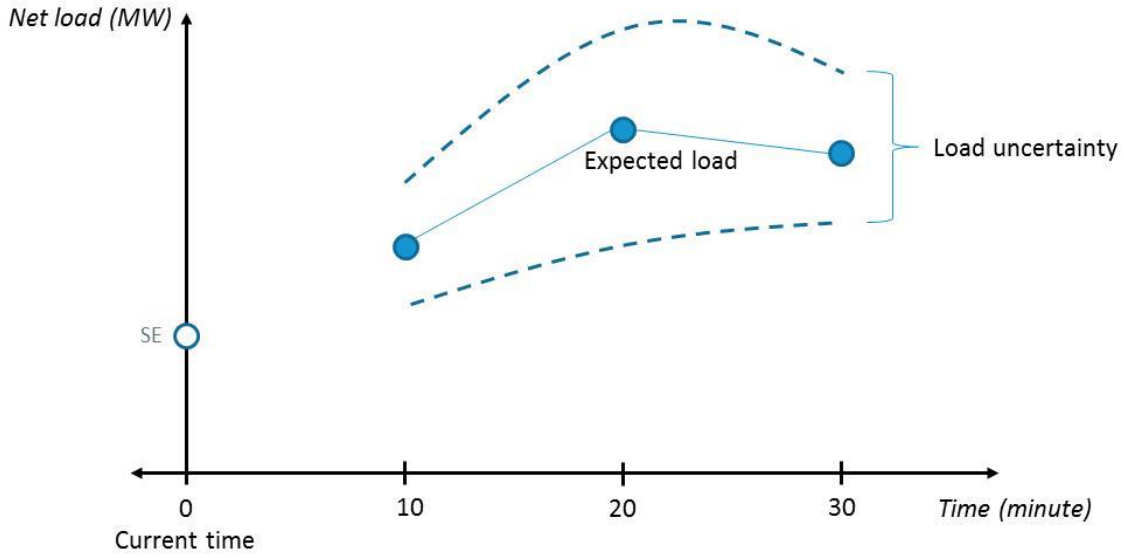
- Consider the settlement for Time T
  - Δp_t^{T} : the cleared deviation from the net existing position in problem t
  - $\mathrm{LMP}_t^{\mathrm{T}}$: the cleared price in problem t
  - $p^{\mathrm{T}}, \mathrm{LMP}^{\mathrm{T}}$: the final (spot) cleared quantity and price
- The total settlement for a generator is

$$\overbrace{\left(\mathrm{LMP}_0^{\mathrm{T}} - \mathrm{LMP}^{\mathrm{T}}\right)\Delta p_0^{\mathrm{T}} + \left(\mathrm{LMP}_1^{\mathrm{T}} - \mathrm{LMP}^{\mathrm{T}}\right)\Delta p_1^{\mathrm{T}} + \cdots + \left(\mathrm{LMP}_{\mathrm{T}-1}^{\mathrm{T}} - \mathrm{LMP}^{\mathrm{T}}\right)\Delta p_{\mathrm{T}-1}^{\mathrm{T}}}^{\text{Cash settlement of futures positions}}$$

$$+ \quad \underbrace{\mathrm{LMP}^{\mathrm{T}}\, p^{\mathrm{T}}}_{\text{Spot market settlement}}$$

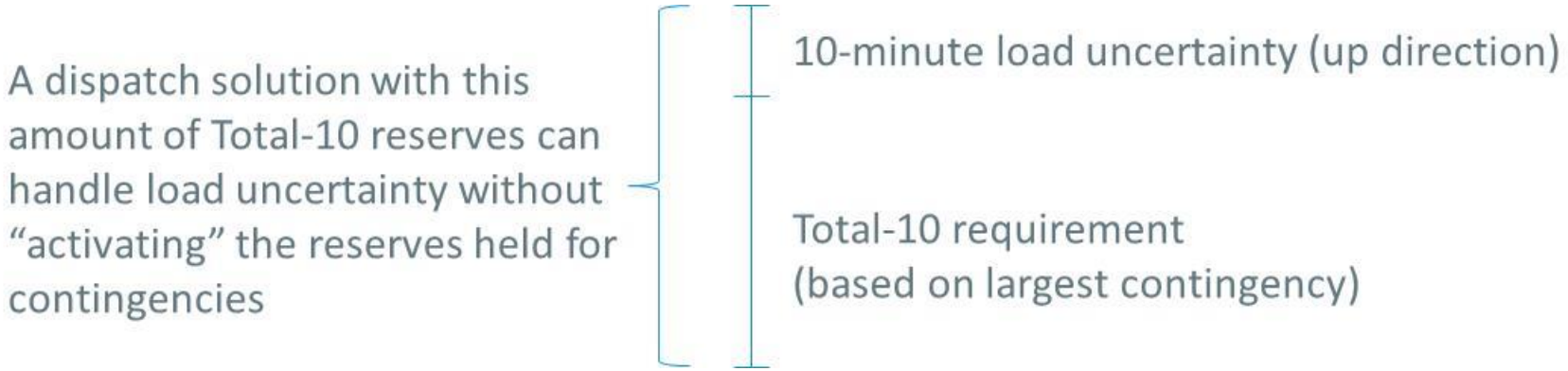
Multi-period pricing. Uncertainty

- Multi-period pricing is useful for expected load changes but may not help with load uncertainty
  - Load uncertainty for Time 10 is handled by AGC
  - Load uncertainty for Times 20-30 can be problematic (economic dispatch runs the system “as lean as possible”)



Multi-period pricing. Uncertainty

- Consider increasing the Total-10 reserve requirement to address load uncertainty for Times 20 – 30
- NERC standards specify a lower bound for reserves
  - **Important question: How is an unexpected net load increase different from a generator contingency?**



Advantages

- If the horizon is longer than the required ramp, the dispatch is efficient
- Each ISO dispatch decision is paid at the associated clearing price
  - Adequate dispatch-following incentives (i.e., no guessing about how much binding price will differ from advisory price)

Disadvantages

- Appropriate time horizon for a multi-period dispatch problem is difficult to determine, especially when commitment optimization and hourly bidding are considered
- More complex RT settlement and uplift calculations
- Uncertainty is not directly addressed
  - Possible solution: Increased Total-10 requirement

CONCLUSION

- ISOs need flexibility to address expected load changes and uncertainty, both expected to increase over time
- Current RT methods have problems with **Dispatch efficiency** or **Compensation**
- Ramp products are poorly defined and can only address certain reliability issues
- Multi-period pricing is promising for expected load changes
  - Difficult to implement
  - Additional changes needed for load uncertainty
- NEXT STEPS: Quantify ($) the benefits and consequences of the current and proposed flexibility approaches