Flexiramp: Some Economic Principles

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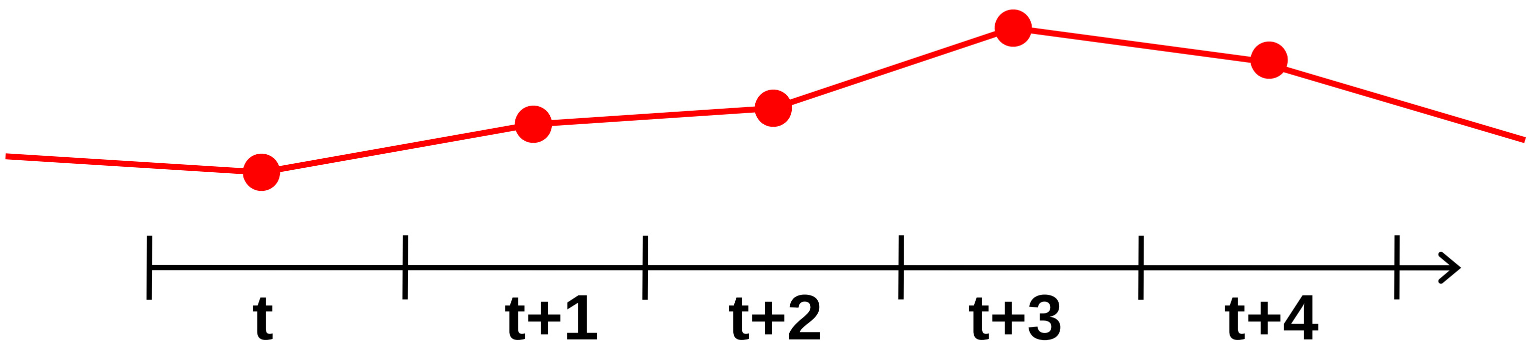
Needs for Ramp

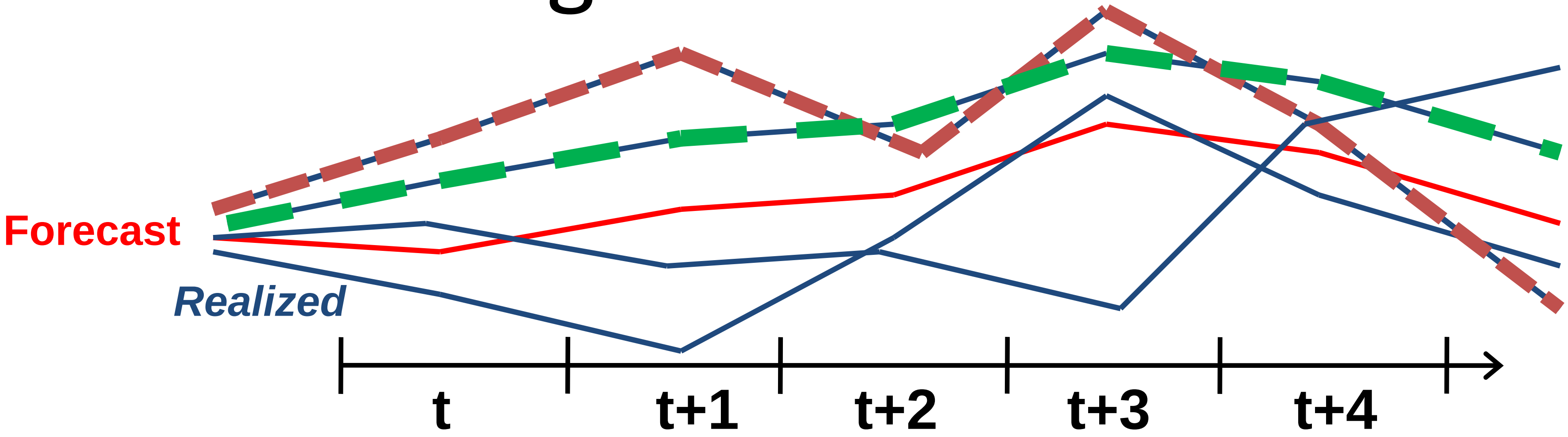
- Forecasted net load ramp (interval-to-interval)
  - Priced correctly (usually) by market software
- Interval net load forecast errors
  - Surprisingly high or low load
  - Real interval loads more volatile
  - *Ideal solution:* stochastic programming
  - *Practical:* operating reserves, flexiramp
- Within-interval ramp needs
  - E.g., Import ramps at beginning/end of intervals, within-interval load & wind variability
  - *Ideal solution:* finer intervals
  - *Practical:* regulation, operating reserves

1. Dealing with Forecast Ramp



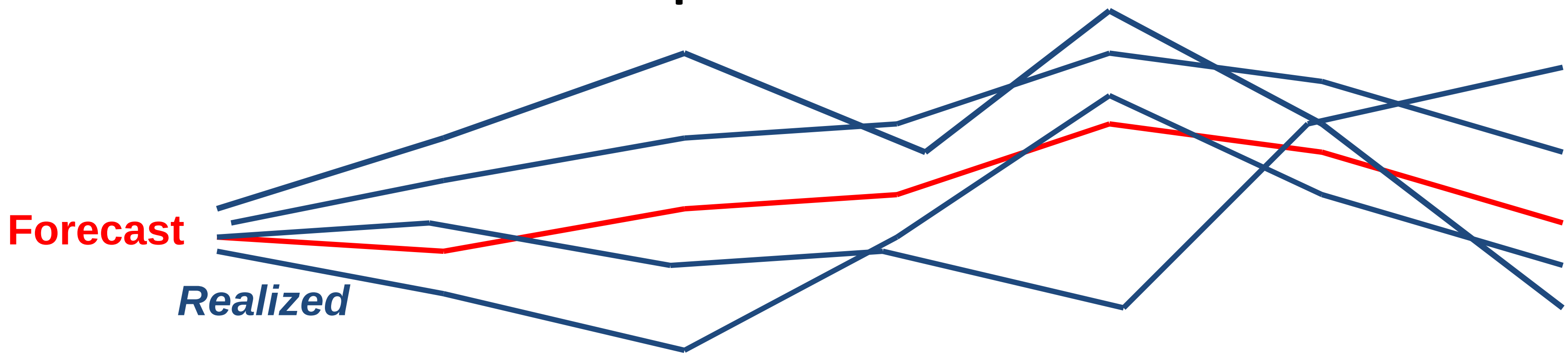
- If:
  - unit ramp constraints correctly represented, and
  - costs "convex" (no lumpy costs, prohibited regions) ....
- Then calculated market prices "support" the solution
  - No unit can increase profit by deviating from schedule
  - Includes up- and downward spikes
    - Upspikes compensate ramping generators for downspikes
- Rolling (RTD) solution & changed forecasts mean that compensating upspikes might not occur

2. Dealing with Forecast errors



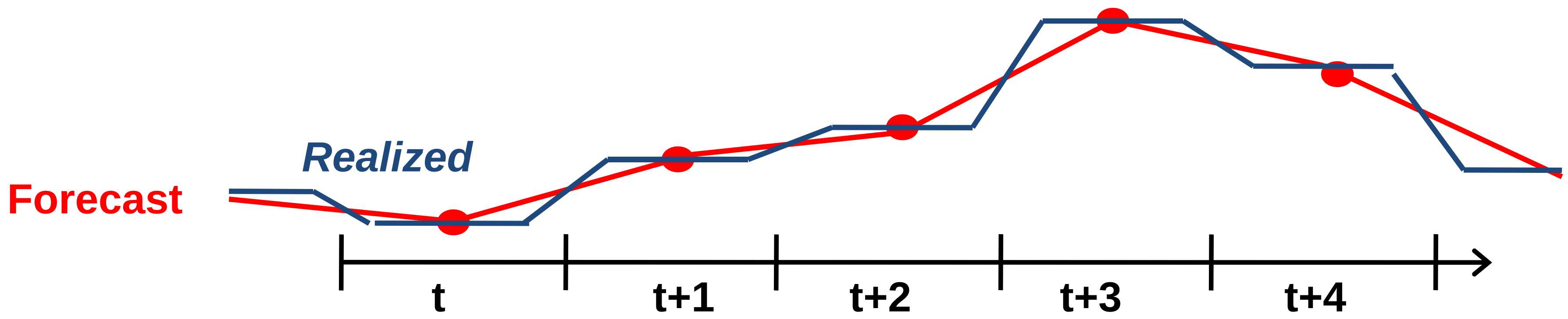
- Actual loads
  - May be systematically higher or lower (3-5% RMS errors in day-ahead forecasts)
  - Higher volatility / steeper ramps
- Ideally: "Stochastic unit commitment"
  - Make commitments considering probabilities of multiple load scenarios (including contingencies)
  - Academic research / vendor development / SCE proposes for long-term vision

Characteristics of Optimal Stochastic Schedules

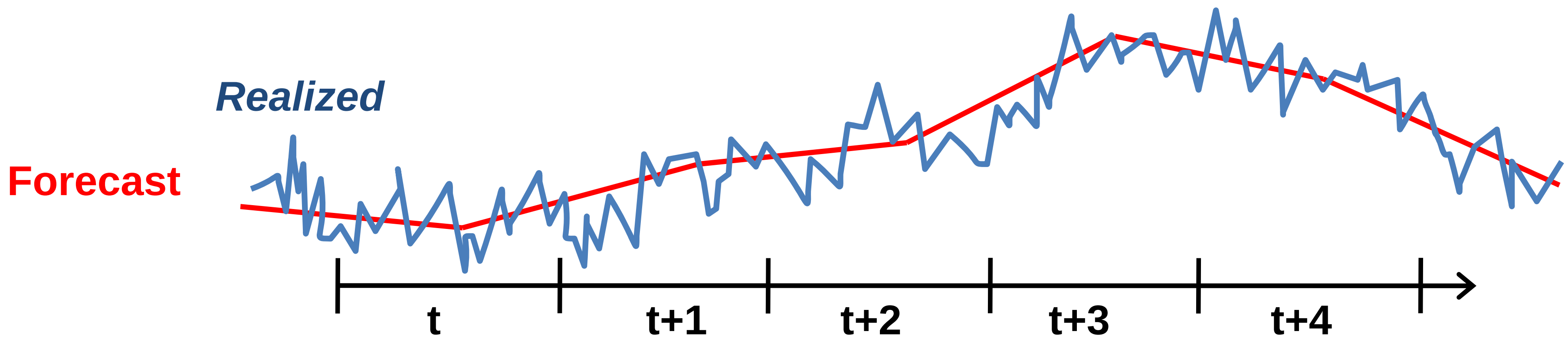


- Objective:
  - Minimize commitment + probability weighted dispatch costs
- Generators:
  - Operate in some scenarios, but not others
  - “Endogenous” reserves / flexiramp
- Disregarding lumpy commitment costs/constraints (assume convex costs) $\Rightarrow$
  - Stochastic energy prices support solution
  - I.e., prospect of possible prices mean that commitment, operation is E(profit) maximizing
  - No separate reserve or flexiramp prices

2. Dealing with Within-Interval Variability



- E.g., start-/end-of-hour import ramps
  - Ramps steeper than forecast (average)



- E.g., Within-interval fluctuations
- Ideal: Smaller intervals, accurate ramp capability models

Reality: Deterministic, Wide Interval Scheduling

- Hueristic Scheduling (IFM, RTPD, RTD):
  - Simple rules (spin, operating reserve, flexiramp requirements)
  - Suboptimal (won't minimize E(cost))
  - Relationship of rules to cost behavior can be counterintuitive
- Some implications of above
  1. Schedule deviations, not overall ramp, is reason for flexiramp
     - Implications for cost-allocation / pricing
  2. Energy prices alone can support (interval-length) energy dispatch *on average*, if commitment optimal
     - Heuristic doesn't need separate capacity payments
       - If neither capped prices nor sub-interval scale variations
     - However, dispatch is not ex post profit maximizing in each scenario
       - E.g., hold back unit (incur opportunity cost) then high P doesn't actually occur later
     - Lack of within-interval P variation $\Rightarrow$ need capacity payment

Implications, *Cont.*

3. Units undispatched for forecast load may have high chance of dispatch; their energy bids affect E(Cost)
   - Should weigh energy bids, P(dispatch) when scheduling reserves
   - Expected margin in energy market should be considered in capacity bids and “opportunity cost” calculations
4. Thoroughly test any heuristic against historic, future conditions