Why a Ramp RA Product?

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Why is the Market Failing (or about to)?

- Issue: Suboptimally small amount of installed ramping capability
- Why doesn't market support it?
  - Distorted prices
  - Missing prices
- What is the cause (market failure)?
- Why is it important to identify the cause?
  - More effective solutions
  - Fewer unintended consequences

Candidate Causes & Solutions

- **Inadequate returns in short-run markets:**
  - *Suppressed price spikes*
    - ➢ ***RA market (1 flavor)***
    - Price caps (missing money)
    - ➢ ***Raise price cap***
    - Averaging intervals (1 hr, 5 minute)
    - ➢ ***Shorter intervals***
  - *Deterministic scheduling*
    - ➢ ***Short- or long-run ramp products***
    - Net Load forecast error
    - Realized ramps more volatile than forecasts
    - ➢ ***Stochastic scheduling***
- **Short-sightedness, risk aversion**
  - *Regulatory risk*
  - *Illiquid RA market*
  - *Long lead times for generation*
  - *Time horizon of RA too short*
  - ➢ ***Multiyear RA***
  - ➢ ***RA Market***

Assumptions

- A limit on the number of starts over some period ("season") for a unit
- Unit always started up in RTUC, and shut down by midnight
  - 5 minute prices relevant
  - Can consider profit in each day separately
  - Multiple starts per day allowed
- Future distribution of 5 minute prices known
  - Can construct a representative time series of prices for remainder of season
  - Actual profitability approximateable by deterministic SCUC
  - Not actually true: prices might be higher or lower than expected.
    - *Ideal: stochastic programming (SDP; see Oren et al.)*
    - *Could have multiple scenarios (hot/cool summer; major outages; etc.)*

Basic Approach

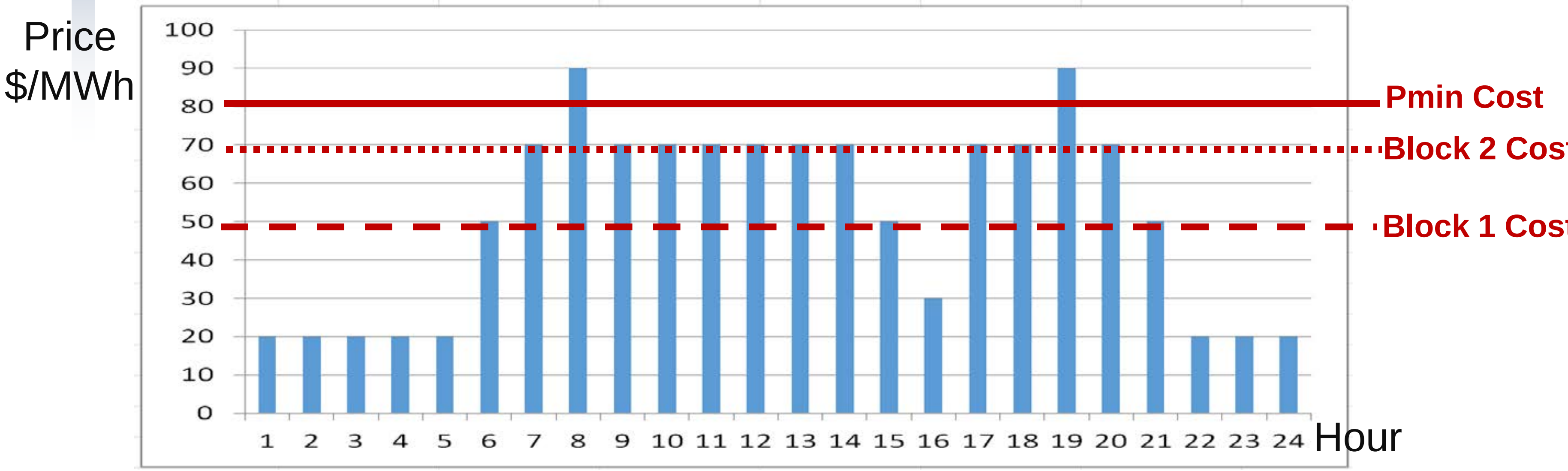
- ***Solve over entire season***
  - ***Decisions***: **timing of starts & shut-downs, and energy/AS production by 5 minute interval**
  - ***Objective:*** **Max Revenues – Variable Costs**
  - ***Constraints:***
    - ***Internal unit commitment, dispatch constraints***
    - ***Total number of starts over seasons = N***
    - ***Perhaps also limits on total operating hours, emissions, …***
  - ***Opportunity Cost:*** **Shrink *N* by 1, note decrease in objective**
- ***Separability of days allows a 2 step procedure that involves calculation one day at a time***
  1. **For each day, calculate optimal commitment in a single day given 1, 2, 3, … starts**
     - **Note gross margin for each day *d* for each # of starts *n*: GM(*d*,*n*)**
     - **A simple single-unit unit commitment model for each day**
  2. **Then choose *n* for each *d* in the season to:**

$$\text{Max} \quad \text{Sum}_d \ \text{GM}(d,n)$$

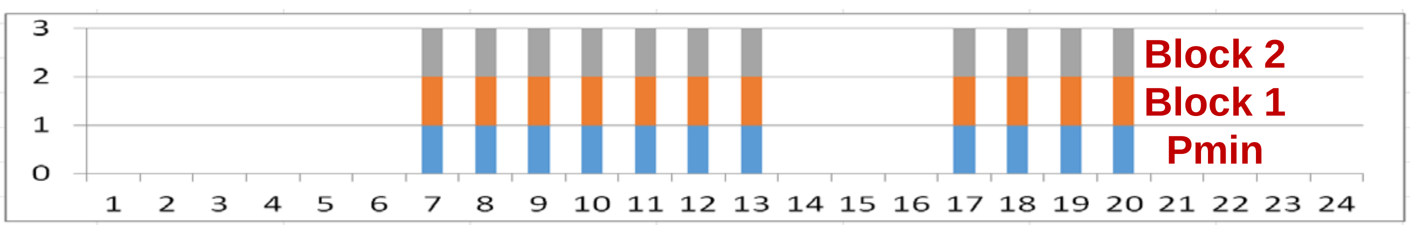
     - **A simple 0-1 program**

Step 1: Unit Commitment to Calculate GM(*d*,*n*)

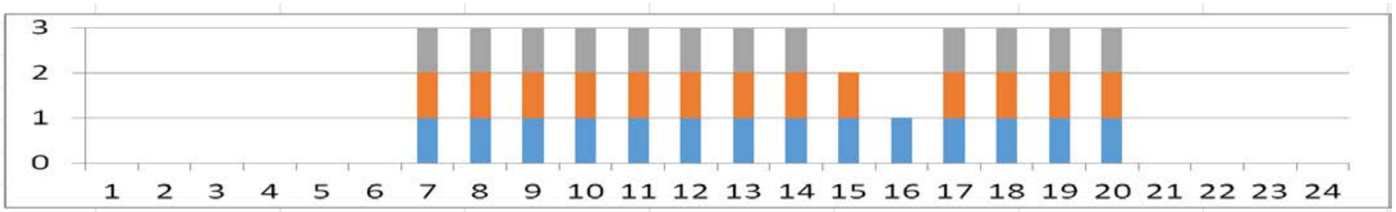
- ***3 MW unit 24 hrs: Pmin = 1 MW, 2 variable blocks***
  - ***$50 start up cost; $80/hr Pmin cost***
  - ***Variable cost block 1 $49/MWh; block 2 $69/MWh***



2 starts: GM = $152



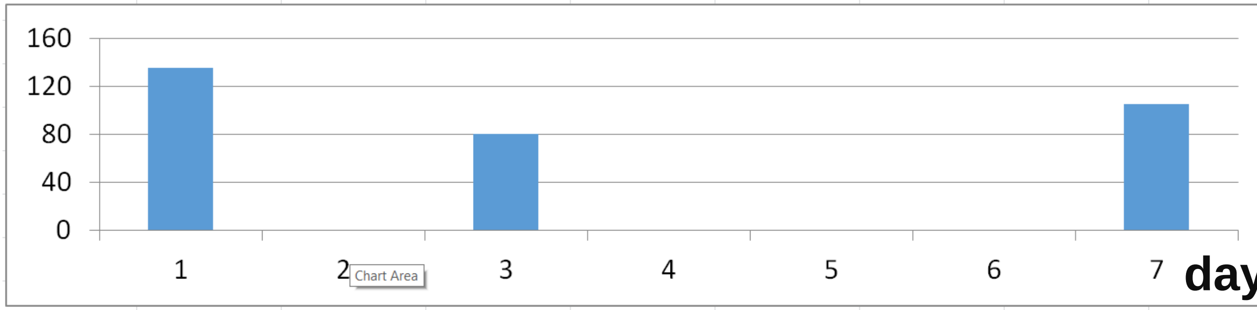
1 start: GM = $135



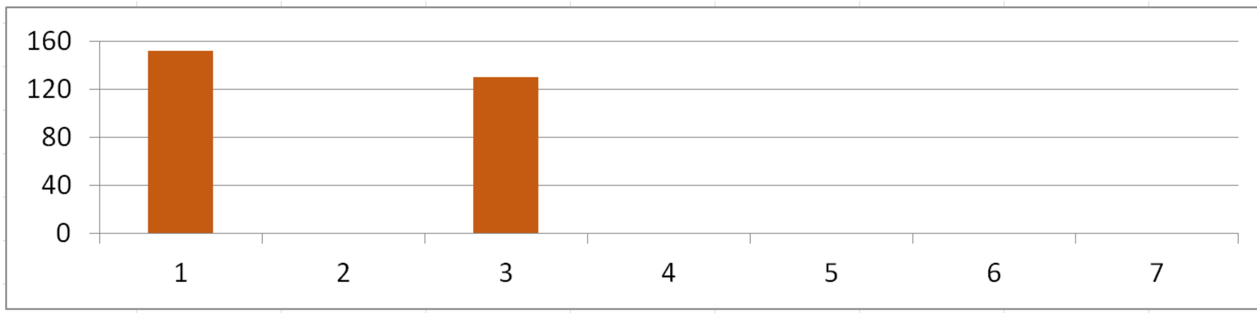
Step 2: Optimal Starts over Season (7 days)

- ***Which 4 starts should be selected to maximize gross margin?***

GM if 1 start



GM if 2 starts



GM if 3 starts