A Procedure for Calculation of Opportunity Costs of Starts

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Question Addressed

- What is opportunity cost of a start?
- That is, how much profit (and, market surplus, assuming competitive conditions) is foregone if we use up one more start today?
  - If starts are limited, one more start today could mean one less start later in the year, and a loss of benefit then
- Proposed use: as “default start-up cost” value in LMPM

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

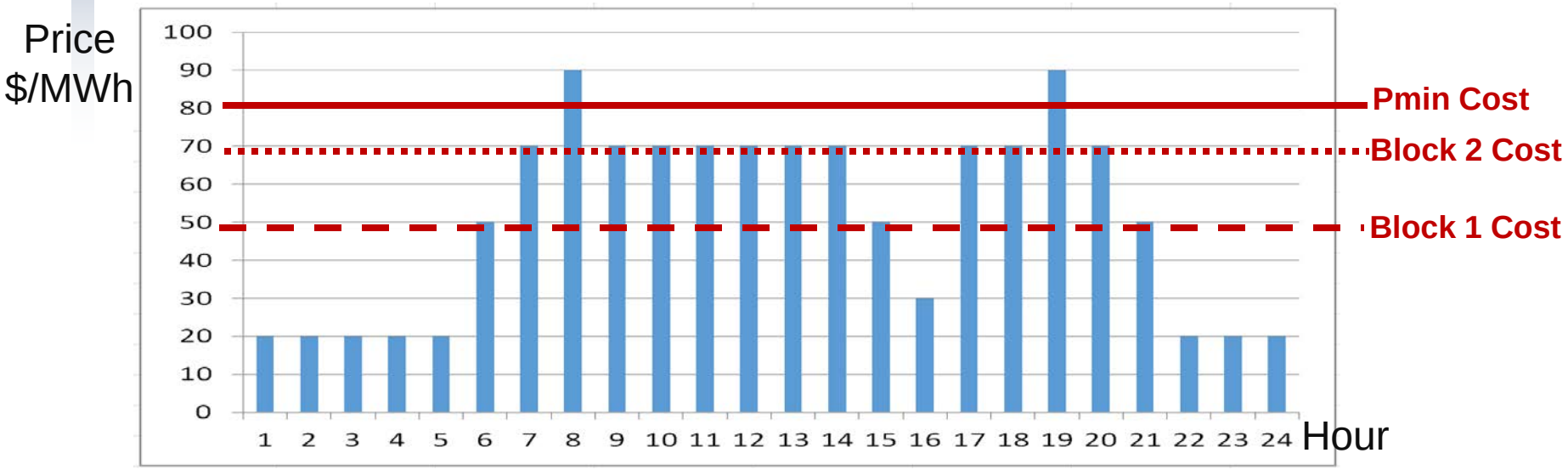
- ***Solve over entire season***
  - ***Decisions*: timing of starts & shut-downs, and energy/AS production by 5 minute interval**
  - ***Objective:* Max Revenues – Variable Costs**
  - ***Constraints:***
    - *Internal unit commitment, dispatch constraints*
    - *Total number of starts over seasons = 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:**

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

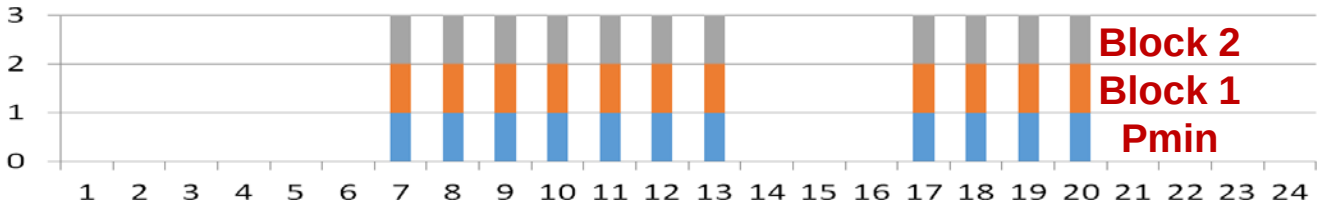
     - **A simple 0-1 program**

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

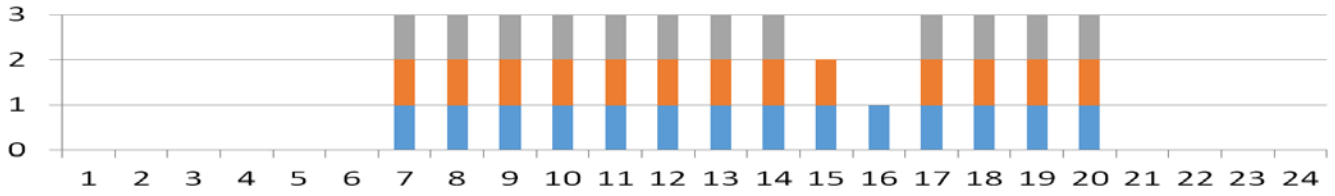
- ***3 MW unit 24 hrs: Pmin = 1 MW, 2 variable blocks***
  - ***$50 start up cost; $80/hr Pmin cost; 3 hr min down time***
  - ***Variable cost block 1 $49/MWh; block 2 $69/MWh***



2 starts: GM = $152



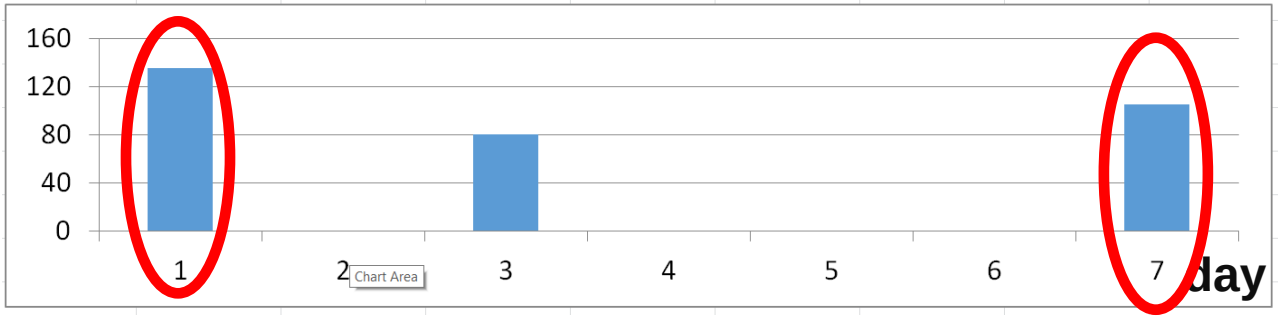
1 start: GM = $135



Step 2: Optimal Starts over Season (7 days)

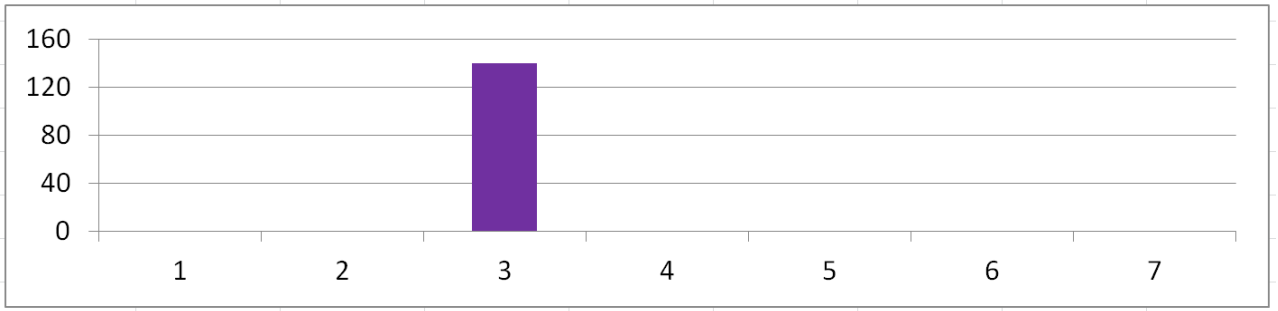
- *Which 4 starts should be selected to maximize gross margin?*

GM if 1 start



GM if 2 starts

GM if 3 starts

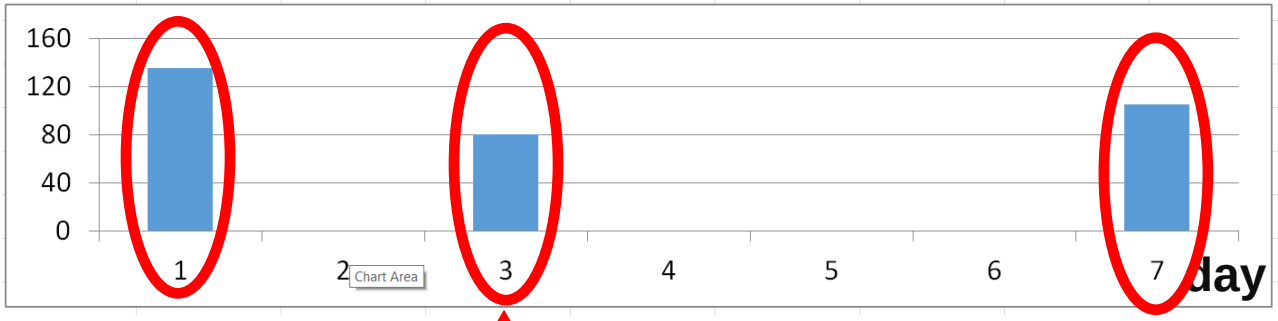


- *Total Gross Margin = $370*

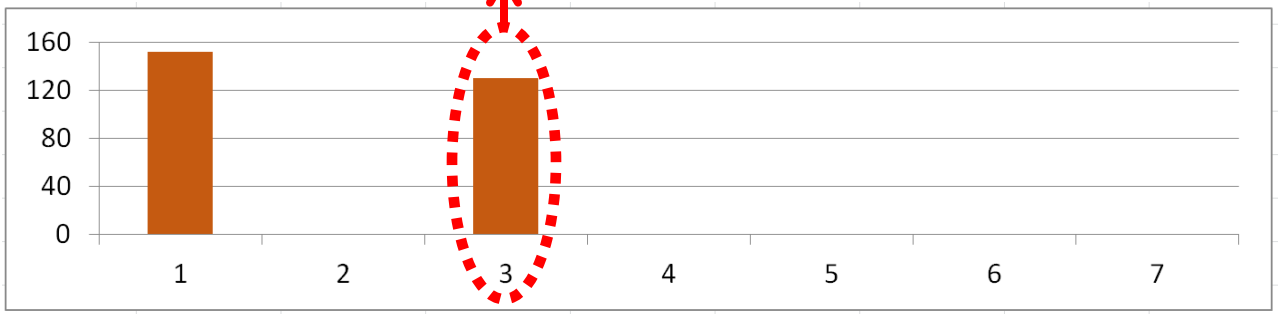
Opportunity Cost Calculation

- *Which 3 starts should be selected to maximize gross margin?*

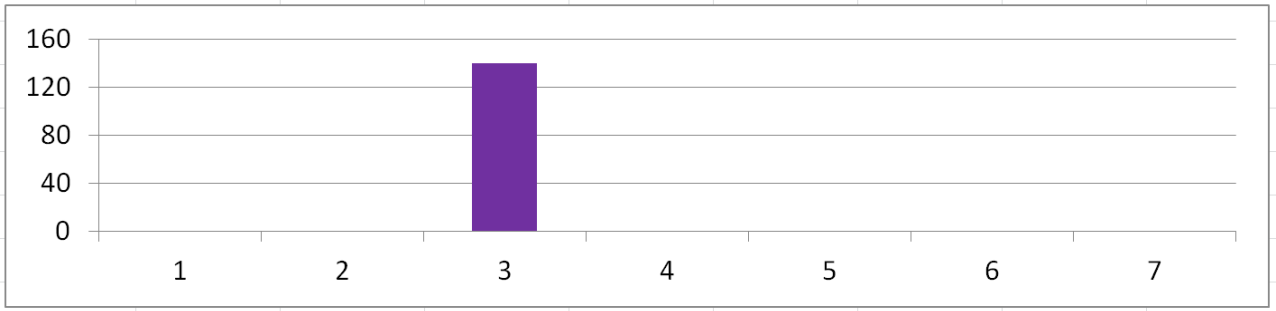
GM if 1 start



GM if 2 starts



GM if 3 starts



- *Total Gross Margin = $320 (was $370)*
- *Opportunity cost = $50*