Discussion on default energy bids for energy storage resources

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Costs for storage resources

- Purpose of a DEB is to serve as a close estimate of marginal cost for use in market power mitigation processes

- Storage resource costs differ from those of traditional generators

- Need to identify, understand, and model storage costs to use resources efficiently

Costs for storage resources

- ISO has identified three primary cost categories:
  - Energy (for charging)
  - Round trip efficiency losses
  - Cycling cost (i.e., cell augmentation costs)

- Storage resources also face unique opportunity costs over time. Actions in the current interval are only possible by forgoing an opportunity in a future interval.

- Charge or discharge when only explicit maintenance and charging costs are covered will be inefficient if opportunity cost not considered.

Modeling of storage resource costs

- Need to consider all short-run marginal cost in DEB, including opportunity costs.

- Opportunity cost concept is similar for any storage resource, so only maintenance cost needs to be technology specific. Extends beyond lithium-ion.

- How to model?

  – Simplified approaches considered by other ISO/RTOs captures some scenarios

  – A more complex model could adapt to all scenarios

Profit maximization for a storage resource

Given an assumption of state-of-charge at the beginning of hour j, what is max expected profit over rest of the day[1]?

$$\max_{C,D,S} \sum_{i=j}^{N} P_i(D_i - C_i)$$

$$= \boxed{\max_{C,D,S} P_j\left(D_j - C_j\right) + \sum_{i=j+1}^{N} P_i(D_i - C_i)}$$

s.to:

$$S_j = S_0 + \eta\bar{C}_j - \bar{D}_j$$

$$S_{i \neq j} = S_{i-1} + \eta C_i - D_i$$

$$0 \leq D_i \leq k$$

$$0 \leq C_i \leq k$$

$$0 \leq S_i \leq hk$$

$$C_i D_i = 0$$

- Only energy arbitrage considered here, but could expand to additional costs and future horizon profit opportunities.

[1] General form for profit max adapted from: B.C. Salles, M., Huang, J., Aziz, M., and Hogan, W., 2017. Potential Arbitrage Revenue of Energy Storage Systems in PJM. Energies 10(8), 1100. http://www.mdpi.com/1996-1073/10/8/1100/pdf.

Profit maximization as for basis marginal cost estimation

- Estimate short-run marginal cost by finding prices at which profit max dispatch changes

- Estimates of short-run marginal cost will account for opportunity cost of foregone profits, charging, and other cost as applicable

- Two optimization problems provide framework:

$$\pi^* = \underset{C,D,S}{\text{Max}} \quad P_j\left(D_j - C_j\right) + \sum_{i=j+1}^{N} P_i(D_i - C_i)$$

$$\underset{C,D,S}{\text{Max/Min}} \; P_j = \frac{\pi^* - \sum_{i=j+1}^{N} P_i(D_i - C_i)}{(D_j - C_j)}$$

s.to Constraints of problem (1), and

$$D_j = \bar{D}_j$$

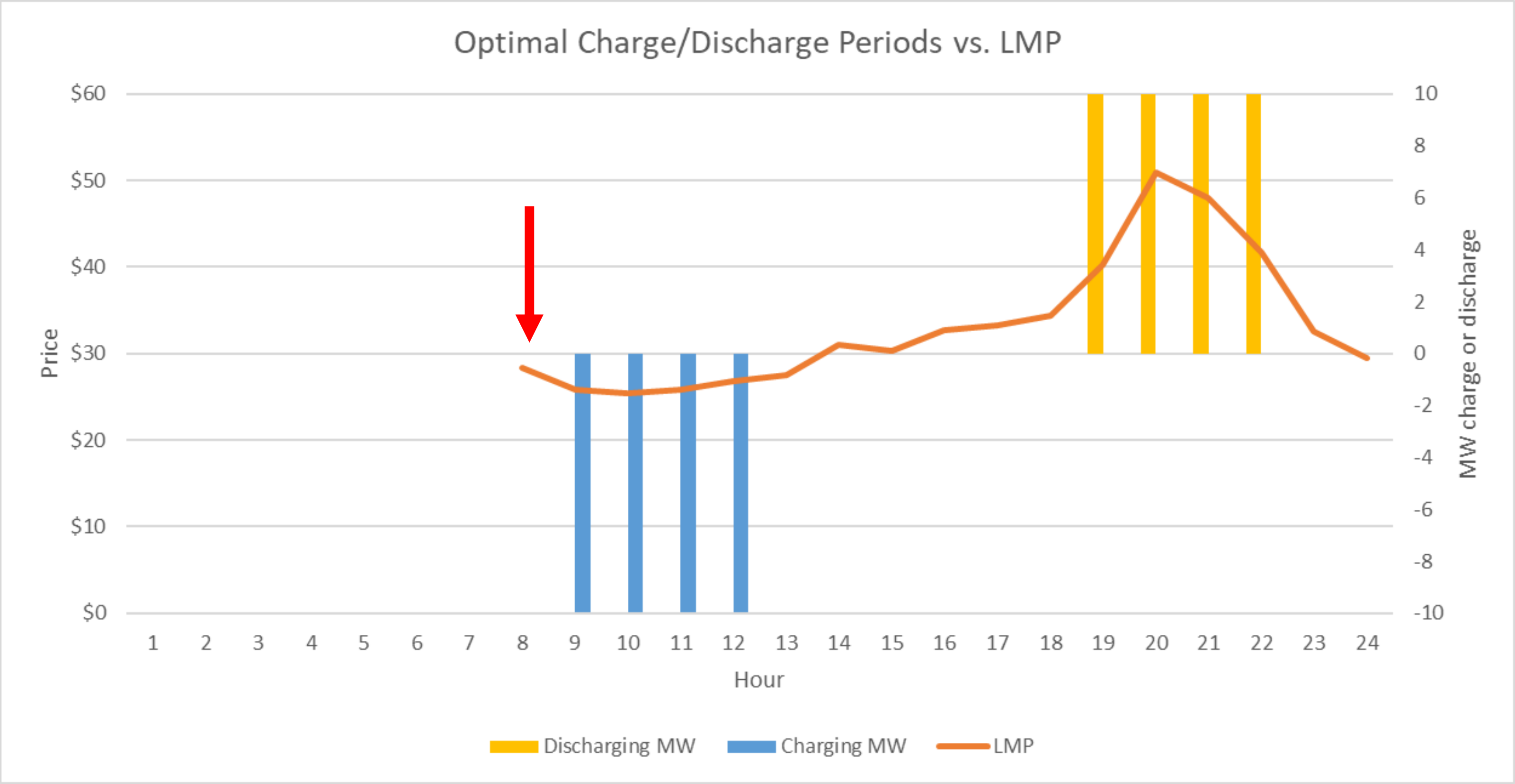
$$C_j = \bar{C}_j$$

Example: marginal cost estimation

- 4 hour battery
- 10MW power rating
- Hour beginning SOC at 5% (2 MWh)
- Roundtrip efficiency loss factor = 0.95
- Solving for Hour Ending 8 (j = 8)

$$\pi^* = \underset{C,D,S}{\text{Max}} \quad P_j\left(D_j - C_j\right) + \sum_{i=j+1}^{N} P_i(D_i - C_i)$$

$$= \$769.01$$

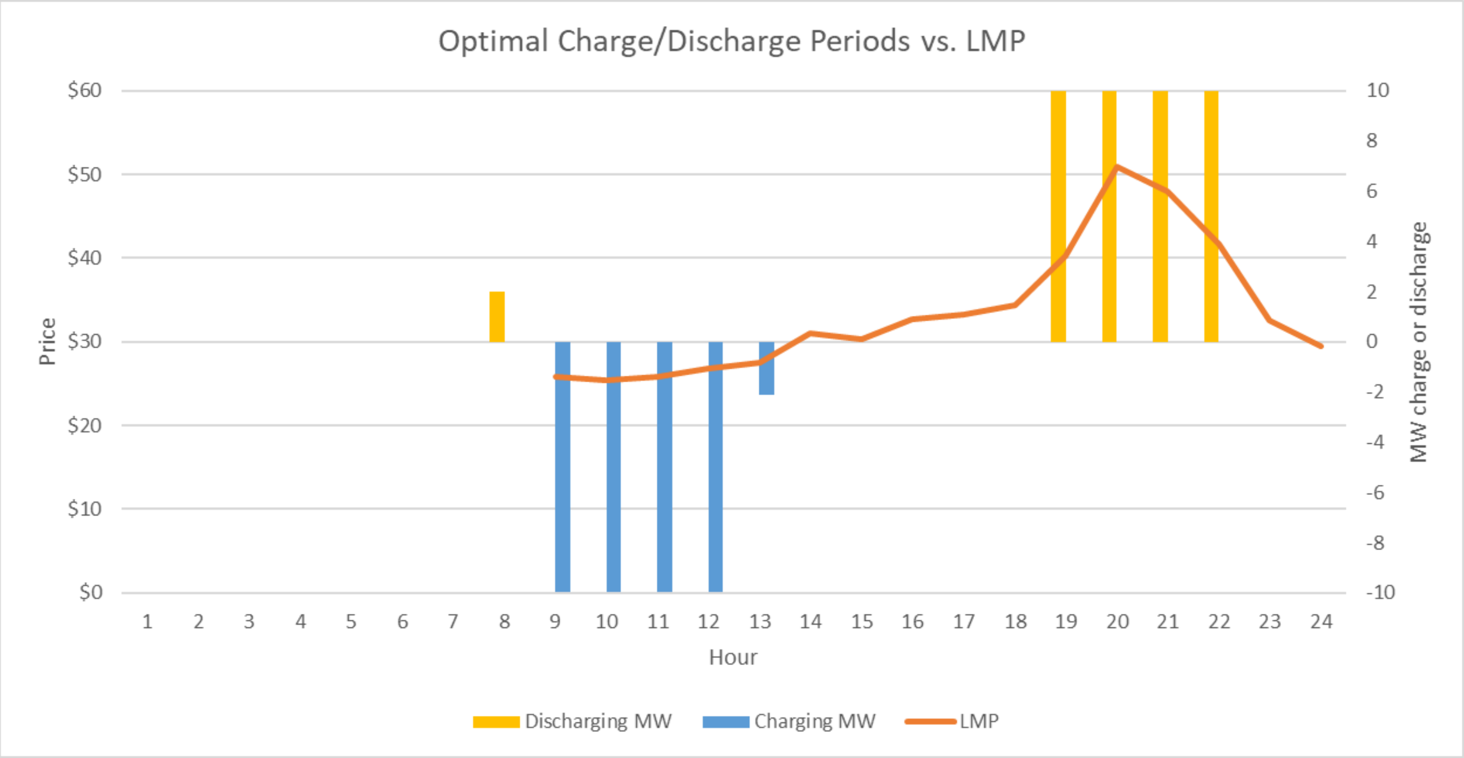


Example: marginal cost estimation (continued)

- Use max profit in problem formulation
- Constrain to max possible discharge= 2.
- Solution is estimate of marginal cost for discharging range = cost of replacement charging in HR 13: LMP / RTE losses

$$\underset{C,D,S}{\text{Min}}\ P_j = \frac{\pi^* - \sum_{i=j+1}^{N} P_i(D_i - C_i)}{(D_j - C_j)}$$

$$= \$28.999$$

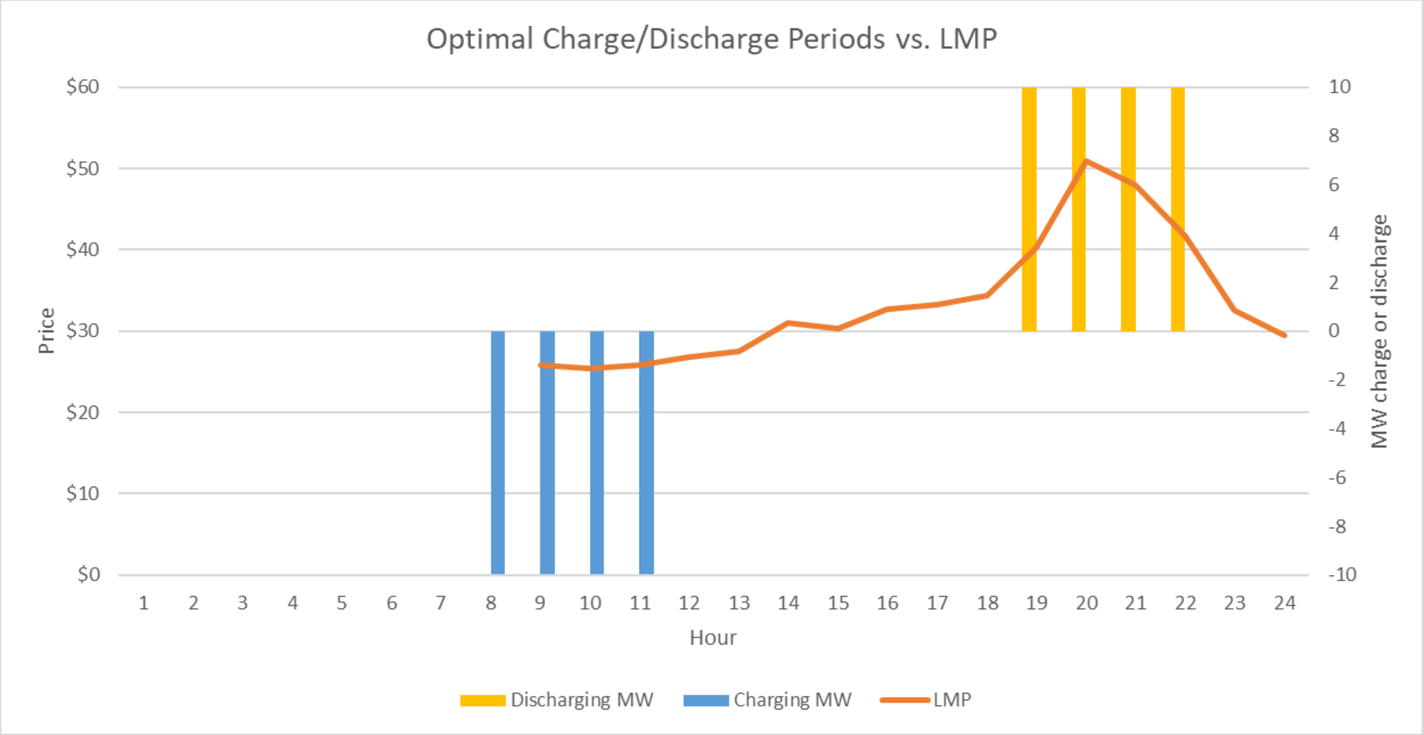


Example: marginal cost estimation (continued)

- Use max profit in problem formulation
- Constrain charging to charge max = 10.
- Solution is estimate of marginal cost for charging range: 1-to-1 tradeoff with highest cost optimal charging opportunity in HR 12 (LMP = $26.85)

$$\underset{C,D,S}{\text{Max}} \; P_j = \frac{\pi^* - \sum_{i=j+1}^{N} P_i (D_i - C_i)}{(D_j - C_j)}$$

$$= \$26.85$$



Implementation considerations

- Requires robust price forecast
- Requires assumption of SOC at some point in the future
- Computational requirements
- Even if some simplifying assumptions are required for initial implementation, developing a robust framework now allows for ease of expansion to multiple technologies and relaxation of assumptions as practicable in the future

Contact information

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