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# Energy Storage Evaluation for Grid and Customer Services


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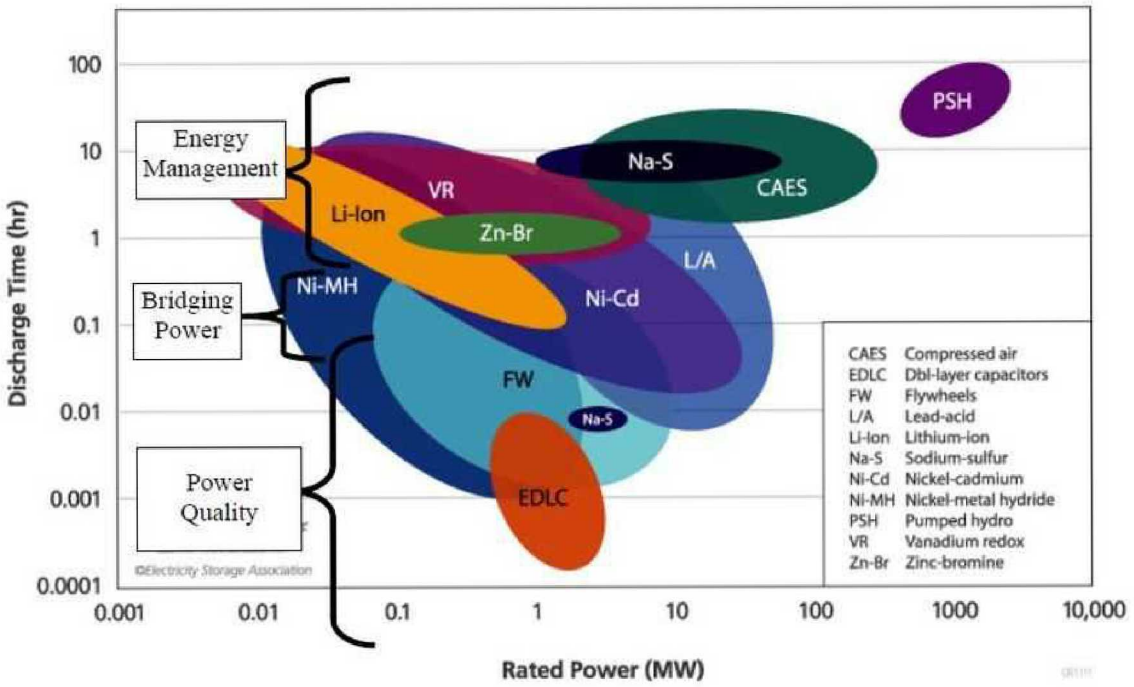
# Outline

- Introduction
- Value streams by category, stakeholder, service type
- Value stacking
- Simulation modeling (tools) for valuation
- Valuation examples
- Recap

# Introduction

- Project development is an exercise in risk management.
- Technical performance impacts economic performance.
- Can the system perform to generate value and make the project financially viable?



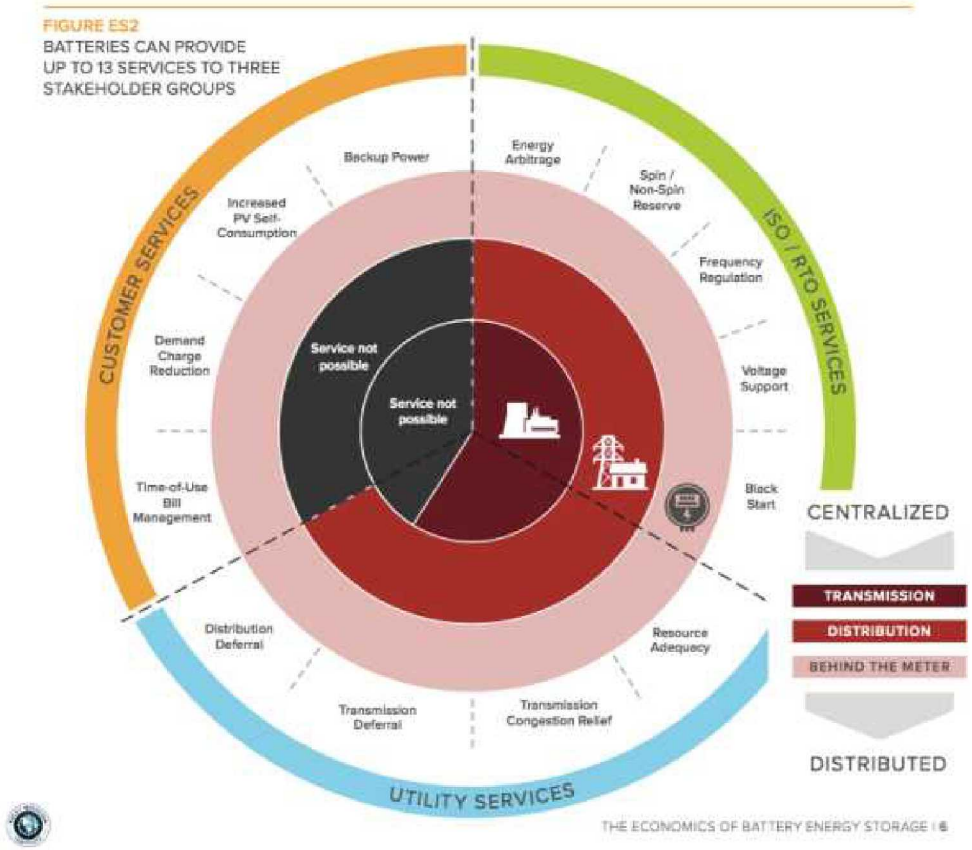

Source: Energy Storage Association

## Energy Storage Performance

"Energy storage systems are not simply reversible energy sinks; they are a highly engineered system with the innate ability to be the most flexible and valuable asset on the power grid."

# Value Streams by Category

| Discrete | Definable | Indeterminate |
| --- | --- | --- |
| • Actual services or products in formal electricity markets<br>• Easily and publicly contracted<br>• ex: frequency regulation | • Typically location-specific<br>• Difficult to generalize to an entire market<br>• ex: black start | • Not easily quantifiable in a systematic valuation basis<br>• In the conversation as a market driver but cannot contract for<br>• ex: resiliency |

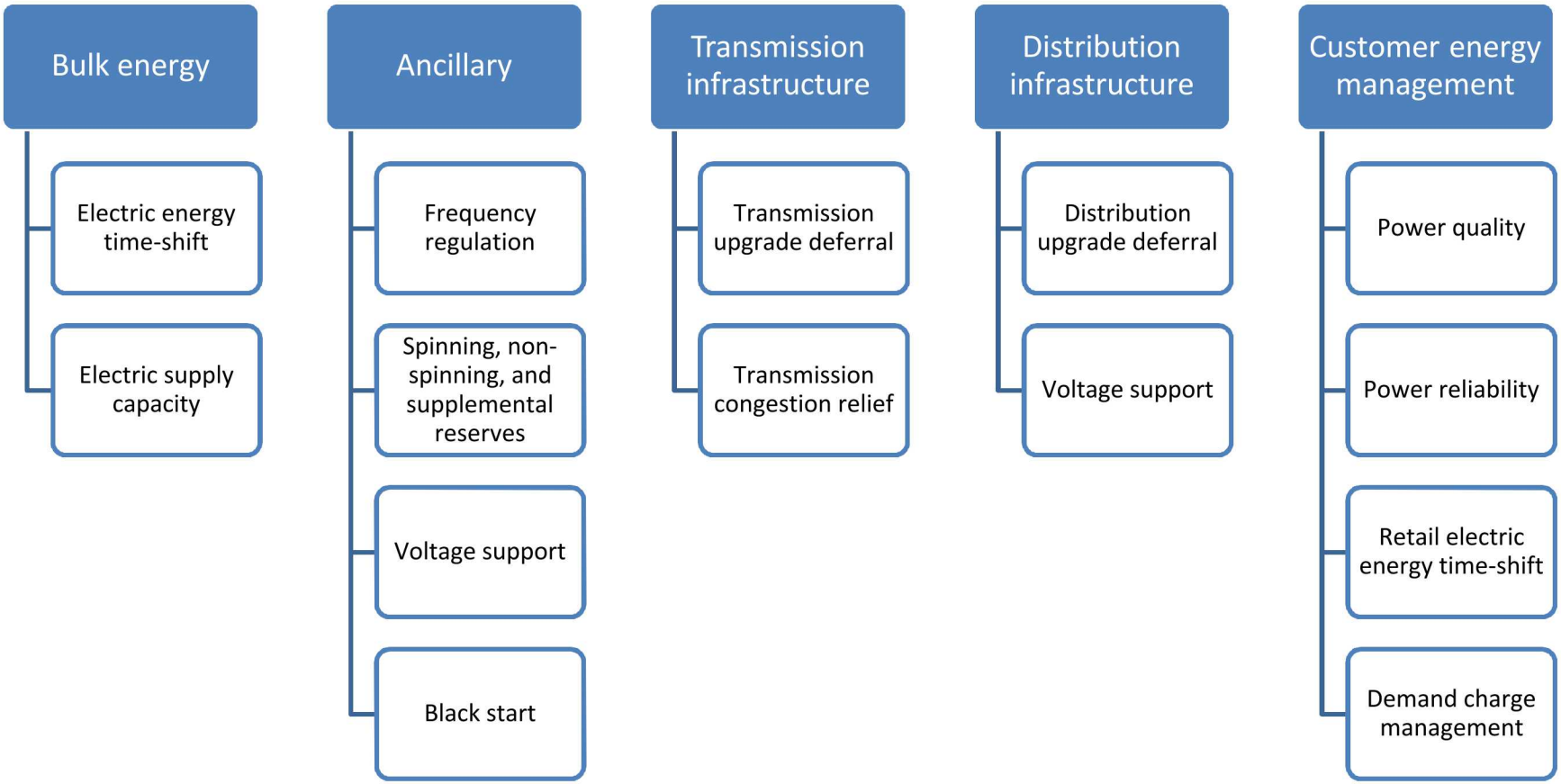



Source: Rocky Mountain Institute, *The Economics of Battery Energy Storage*

## Value Streams By Stakeholder

- Energy storage can provide services at different levels
- Different applications appropriate for different technologies

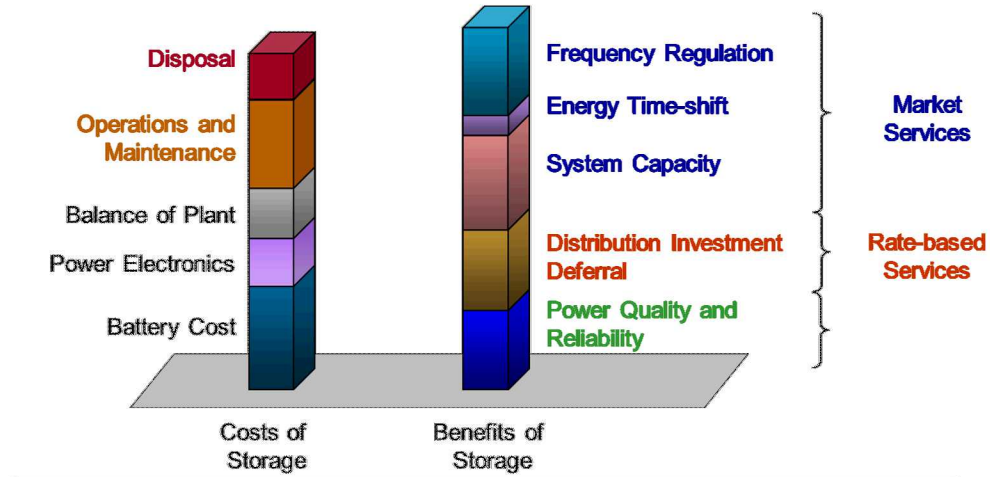
# Value Streams by Service Types



# Other Value Streams

- Hybrid facilities with fossil units or renewable energy assets
- Colocation with large wind/solar facilities
- Onsite usage as backup power or self-generation
- Resiliency for mission critical loads
- Aggregation into “virtual power plants”
- Each individual stream alone is generally insufficient to support the energy storage project
  - Value stacking

# Value Stacking




Source: EPRI

Optimizing the mix of potential applications and operating over it is complex.

- Different technical capabilities
- Each application competes for the system's energy and power
- Best mix and operational strategy for revenue generation may not be the best value

# Simulation Modeling for Valuation

**Target and model value streams**

How state of charge (SOC) management translates to value ($)

**Simulate system performance**

Simulate implementing SOC policy or solve for optimal policy (optimization)

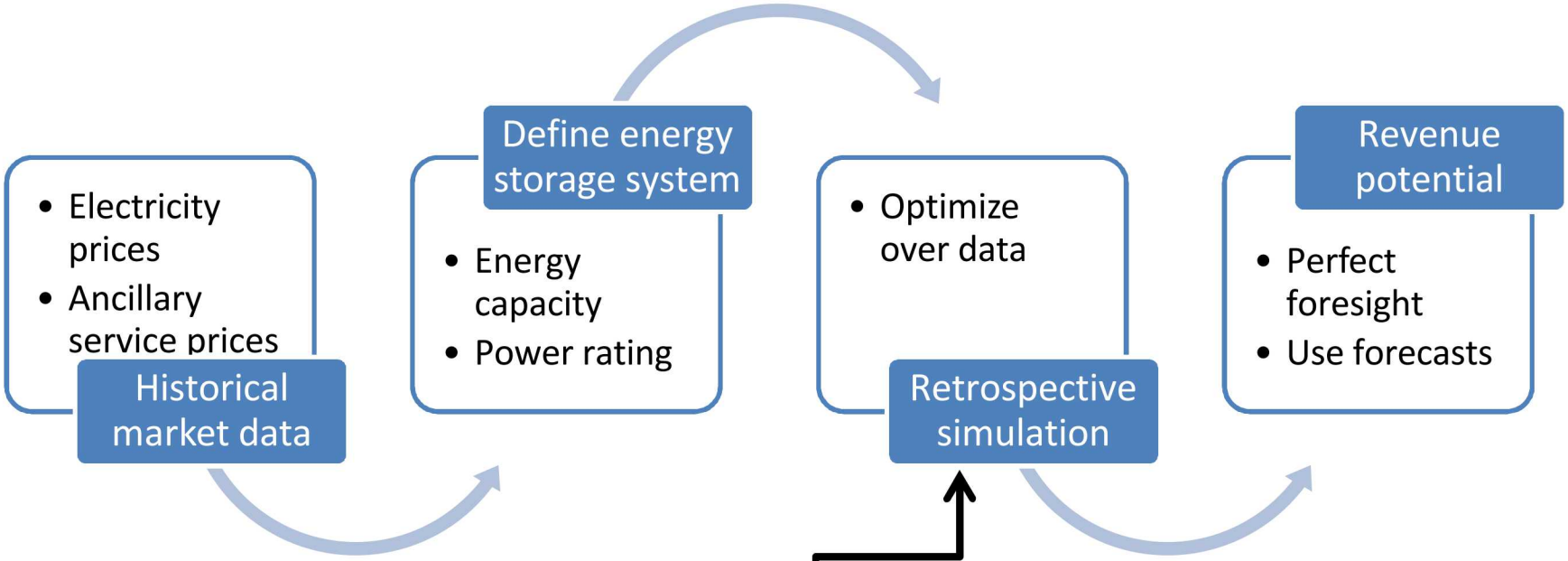
**Extrapolate value from technical performance**

Valuation gives insight into future performance expectations

# Simulation Modeling Tools

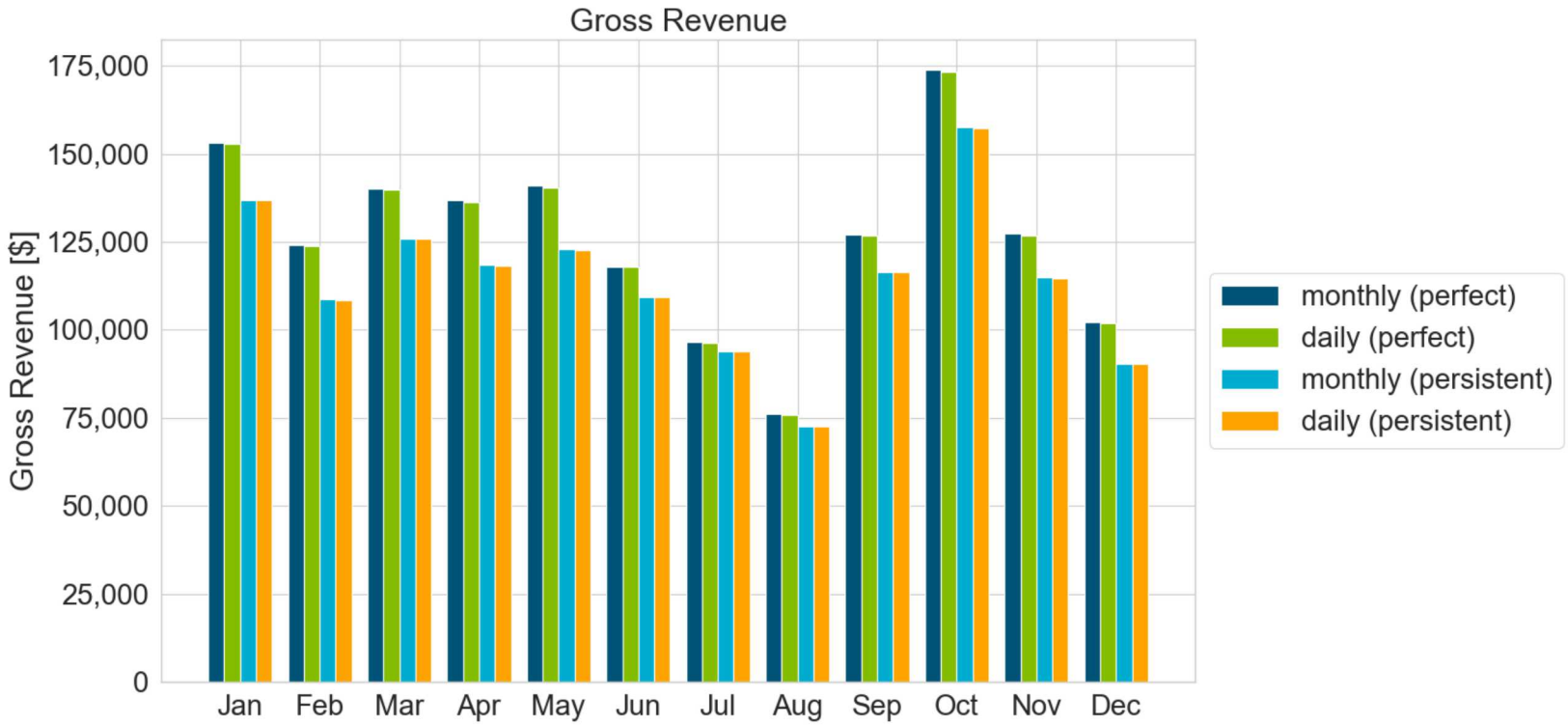
| Pros | Cons |
| --- | --- |
| • Theory and modeling already done<br>• Analysis tools already developed<br>• Compare many, similar projects methodically<br>• Sufficient for most cases | • No “one-size-fits-all”<br>• Fits scenario to model, not the other way around<br>• Difficult to capture non-"discrete" value streams<br>• Modeling implies simplification and assumptions |

# Example: Market Participation



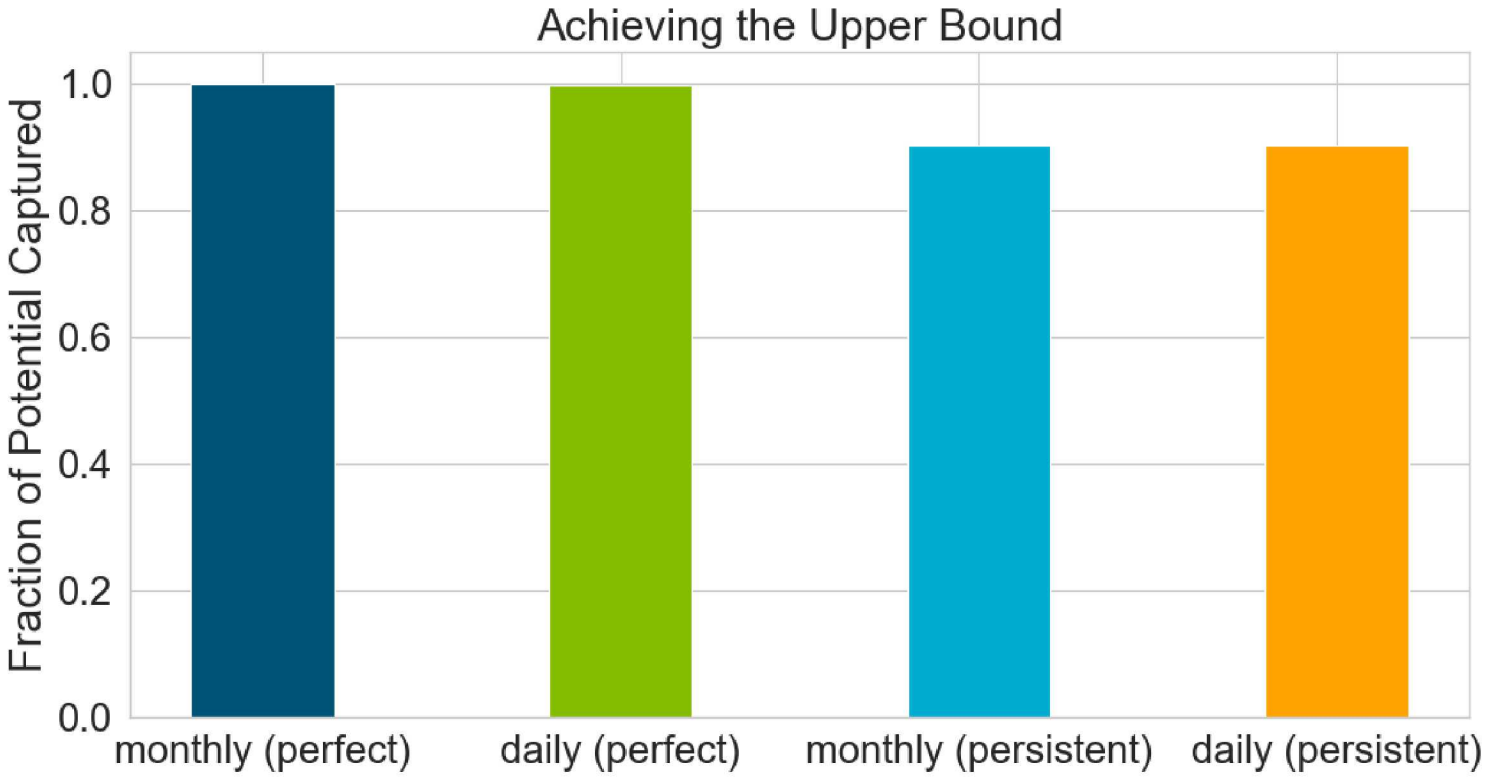

maximize: total revenue generated over time period

subject to: state of charge limits
power/energy limits
other constraints




## Example: Market Participation

- Southwest Power Pool, arbitrage + frequency regulation
- CY 2017, “SPPSOUTH_H” pricing node
- 8 MWh/2 MW ESS

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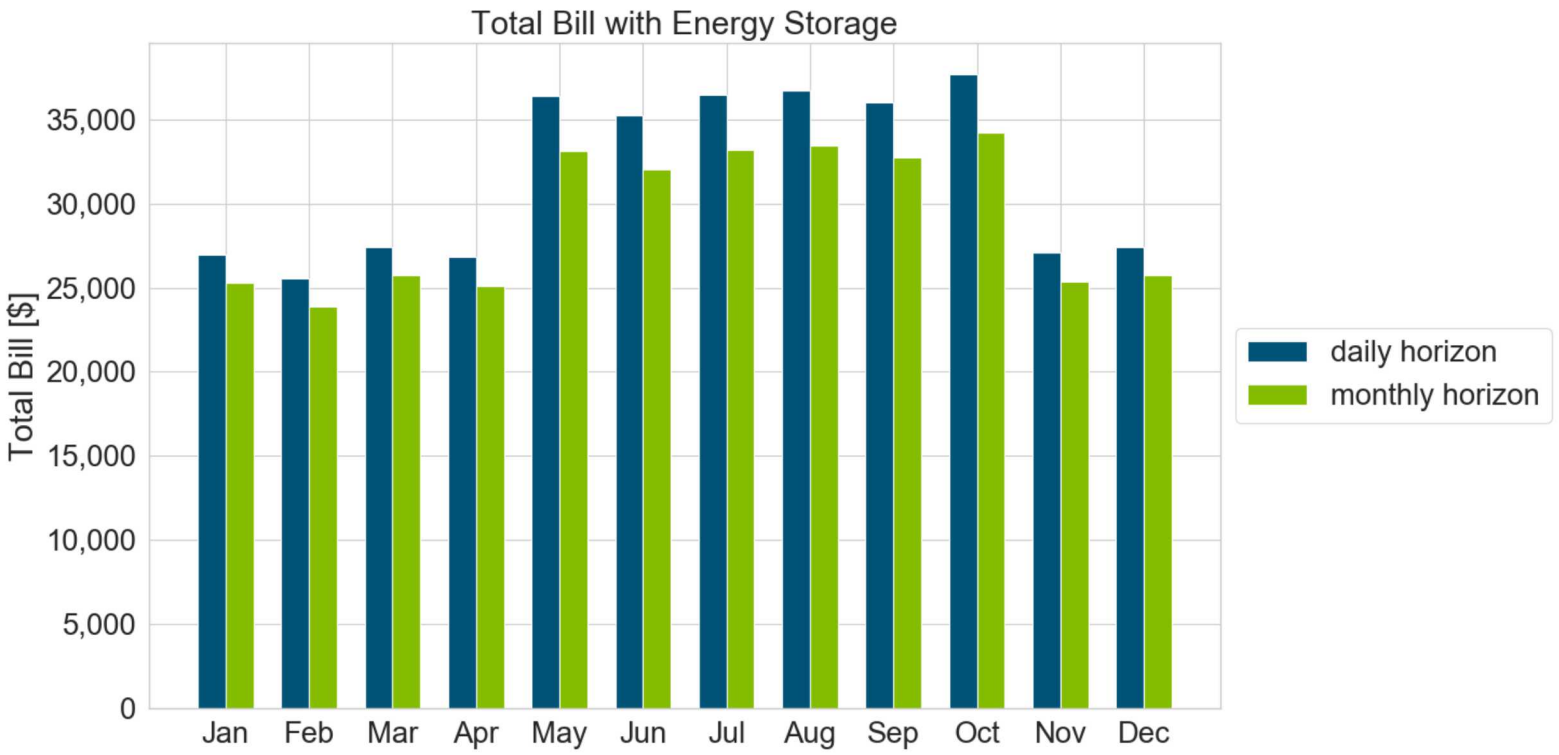
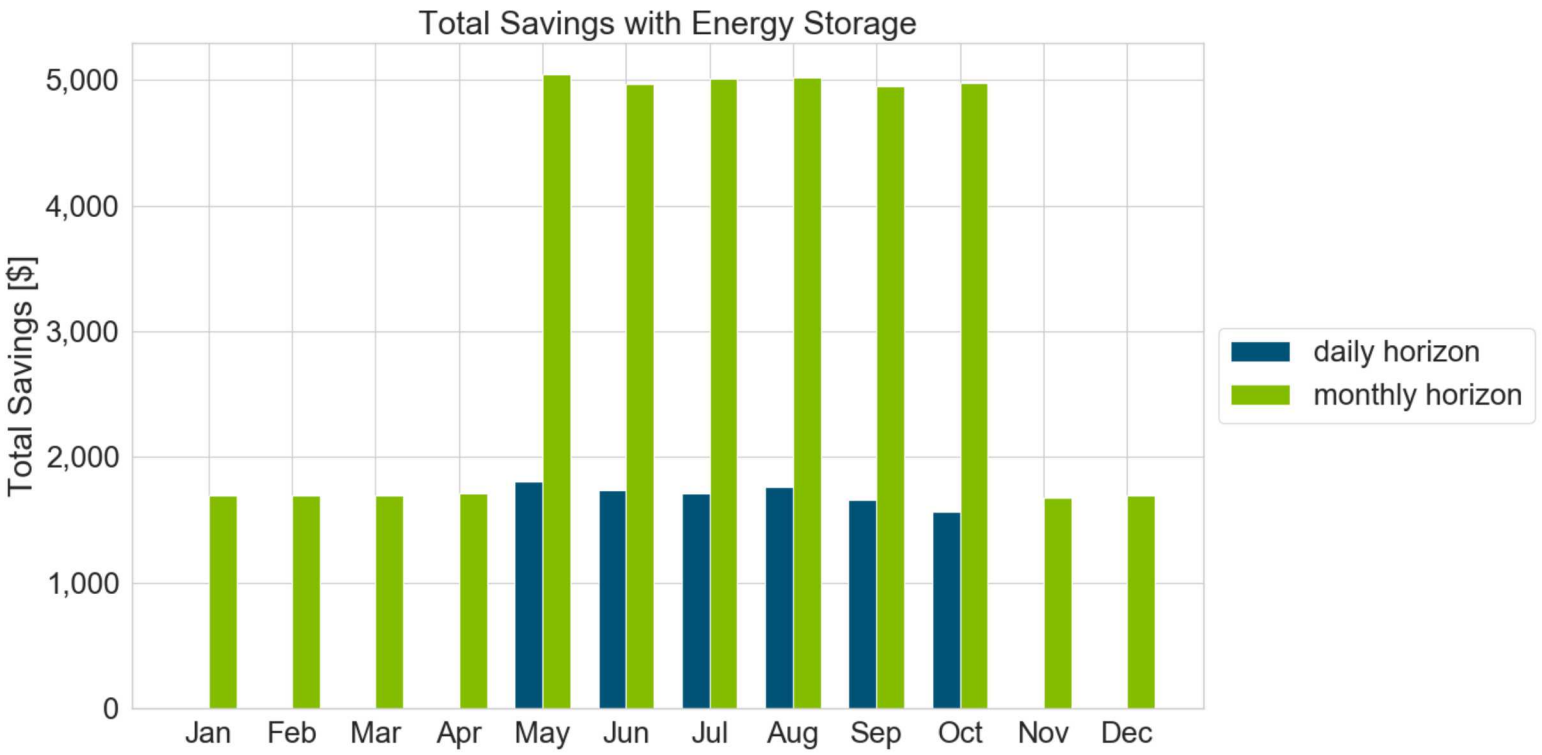



## Example: Bill reduction with behind-the-meter ES

- Pacific Gas & Electric Co.; E-19 Medium General Demand TOU (Secondary, Voluntary)
- Large hotel simulated load profile (TMY3, San Francisco, CA)
- 50 kW PV, 400 kWh/100 kW ESS

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# Recap

- The value provided by energy storage is necessary for an economic model of the project
- Value streams can be discrete, definable, or indeterminate with different degrees of ease in quantifying benefit
- Value stacking is imperative for financial viability, but knowledge of the technical capabilities of the system is key
- Energy storage evaluation should be site- and case-specific, but generic modeling tools can serve as well
- Data-driven simulations for valuation

# Thanks

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