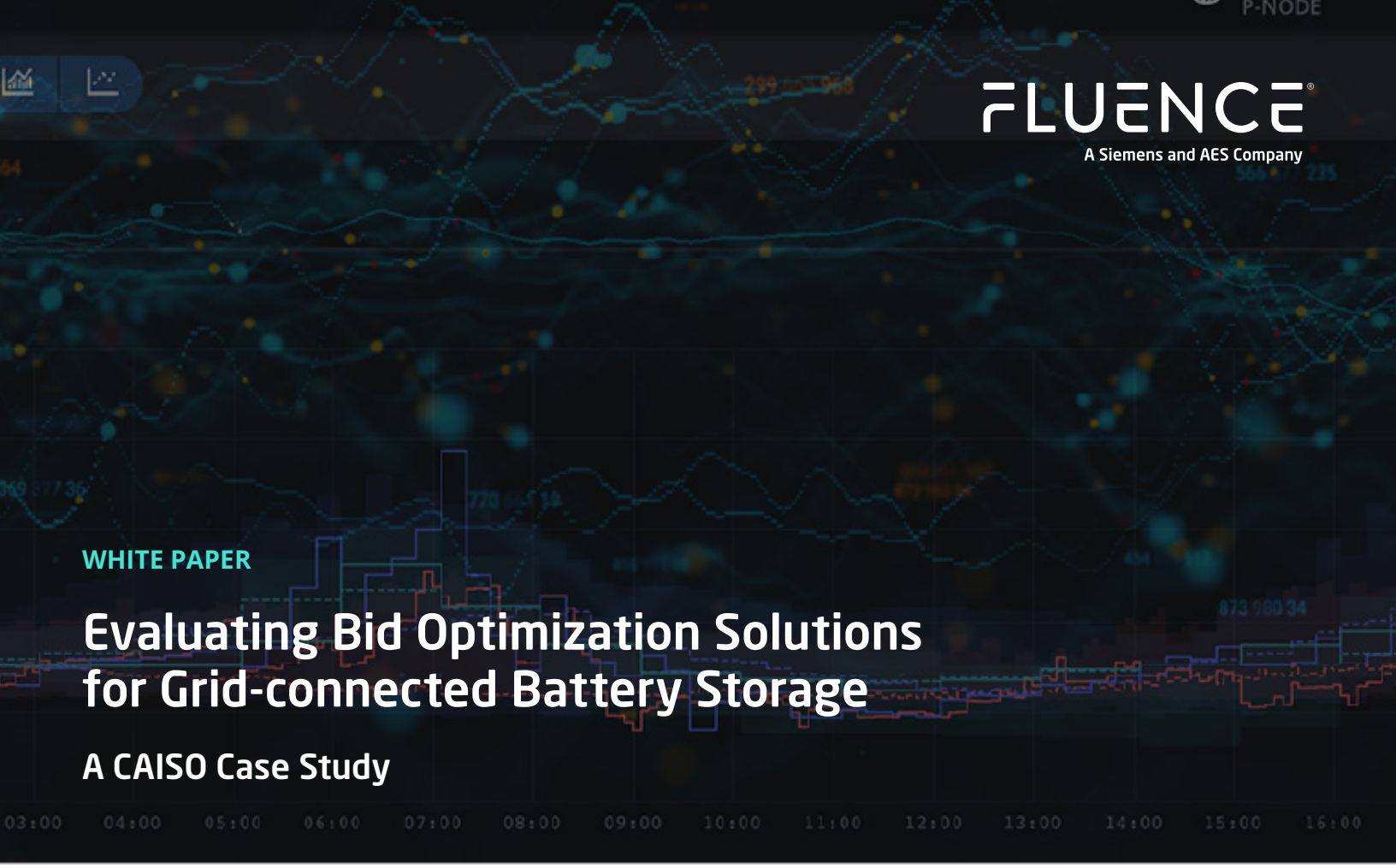


by Mary Lewis, Senior Strategy Associate

Summary

California is proving yet again to be a hotbed of energy innovation. With nearly 4 GW of utility-scale battery storage capacity available across the state as of September 2022[1]—California battery asset owners and operators are facing unprecedented challenges.

Traditional approaches for bidding thermal assets (e.g., based on marginal cost derived from fuel cost and heat rates) or renewables (e.g., based on marginal cost derived from REC value) are not viable for fast ramping, use-limited battery resources. In order to maximize asset revenue, operators must determine when to charge vs. discharge, manage battery state of charge (SOC), navigate day-ahead and real-time forecasts, and comply with CAISO's Non-Generator Resource[2] (NGR) rules.

The legacy and spreadsheet-based approaches used to bid conventional energy assets are too manual and time-consuming to meet the complexity posed by battery storage assets. To meet this new market need, a new class of software-based, algorithmic bidding solutions is fast emerging.

The technical evaluation of algorithmic bidding software platforms is rapidly becoming a critical competency for companies seeking to build and operate dynamic energy assets like battery storage. In order to be successful in this evaluation, asset owners should consider two primary metrics: (1) Revenue uplift (e.g., relative to a human-centric trading strategy) and (2) Percent of Perfect Foresight, or PoP.

Revenue Uplift

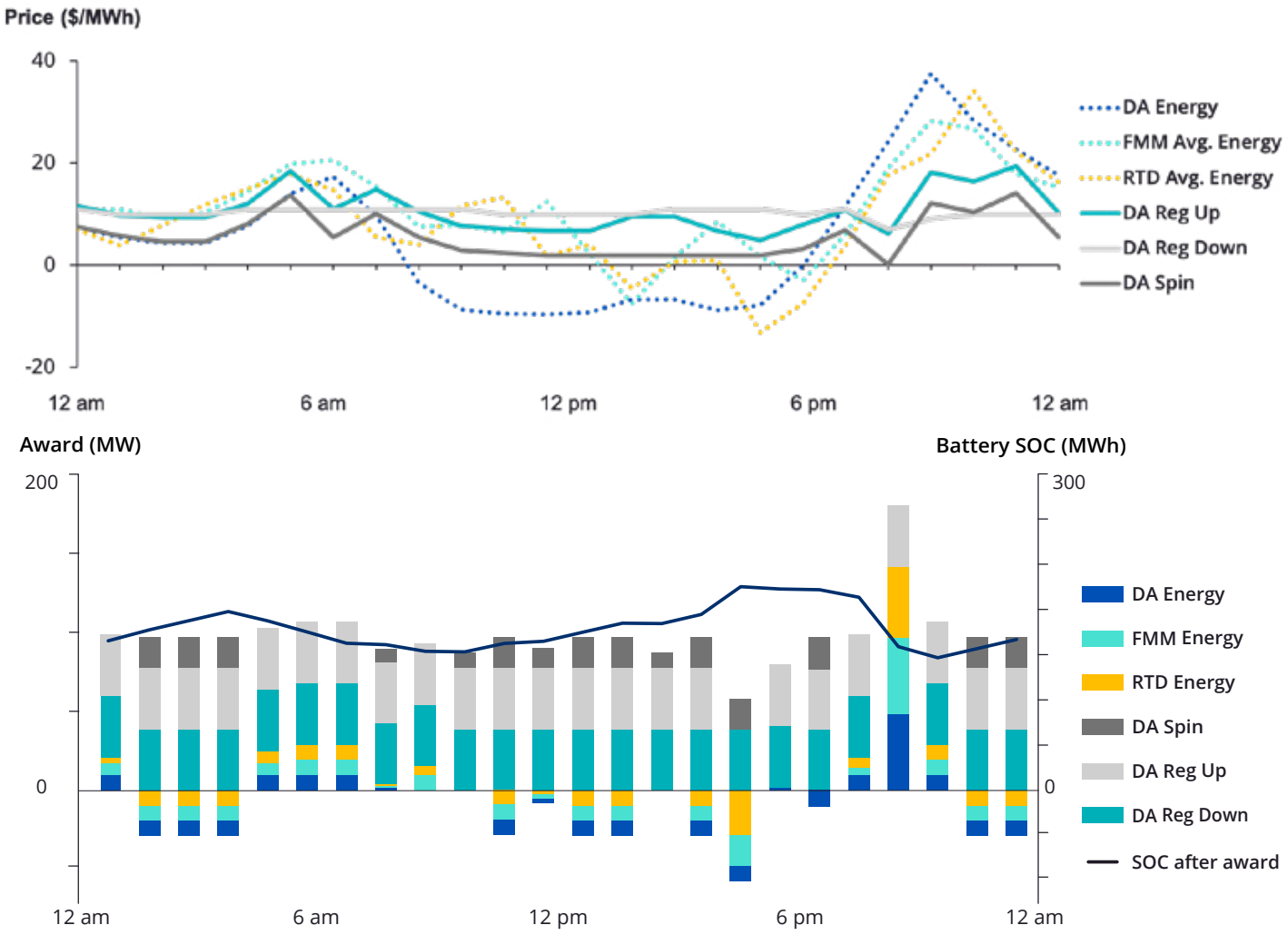
Revenue uplift measures the additional revenue an asset can achieve using an optimized bidding approach, relative to an alternative bidding approach. A revenue uplift analysis allows asset owners to quantify the market value of an algorithmic bidding strategy compared to that of a manual bidding approach for their planned or existing battery storage system. To control for seasonality and volatile market conditions, revenue uplift is calculated by running two scenarios of a year-long backcast[3] using (1) an algorithmic bidding strategy and (2) a manual bidding approach. Each scenario in the analysis simulates performance using specific asset characteristics (e.g., warranty constraints) and actual market price data. Comparing the resulting backcasted revenue of the two scenarios shows asset owners how much value is being left on the table with a manual bidding approach.

DESIGNING AN UPLIFT ANALYSIS

1. Identify a grid location (node)
2. Use specific asset characteristics
3. Control for seasonality
4. Include actual market price data
5. Evaluate hourly results data

A robust revenue uplift analysis should facilitate diving further into market price and award data at the hourly level. For example, Figure 1 below shows asset owners how the battery is co-optimizing across market products while managing state of charge throughout the day with respect to market prices. This level of detail exposes the specific market conditions and bidding decisions that contribute to a divergence in revenue between the algorithmic and manual strategies. A complete analysis shows owners their asset's expected operational revenue using an algorithmic bidding strategy and validates the decision to adopt an algorithmic approach.

FIGURE 1: Example analysis performed with actual Day Ahead Market, Fifteen Minute Market, and Real Time Dispatch prices.
Data covers pricing for May 28, 2019 at HAAS_7_B11 price node and NP-15 AS trading zone; 50MW/200MWh; 1 cycle / day limit; 93% charge efficiency and 95% discharge efficiency; regulation up & down cap of 50 MW



Percent of Perfect Foresight (PoP)

In addition to understanding the value uplift of an algorithmic trading approach relative to a manual approach, asset owners increasingly require capabilities and metrics to evaluate the performance of various algorithmic bidding software platforms. Percent of Perfect Foresight, or PoP, analysis helps asset owners achieve this by evaluating the performance of a selected algorithmic trading approach. Specifically, PoP analysis compares revenue from an operational algorithmic trading approach with the maximum revenue that an asset could have attained if it had perfect knowledge of actual market prices (i.e., "perfect foresight").

PoP equals the Operational Foresight Scenario revenue as a percent of Perfect Foresight Scenario revenue. This measurement demonstrates the algorithmic trading approach's ability to capture the total potential market revenue. A complete PoP analysis also includes hourly bids and market awards that can be evaluated across the scenarios, providing context for the results.

There are two main differences between the operational foresight and perfect foresight scenarios: 1) the forecast itself, and 2) the level of uncertainty that the optimization consumes. Because no operational forecast will perfectly predict future market prices, an insightful forecast should contain confidence intervals and probabilistic values. The confidence intervals help traders assess the uncertainty of an operational forecast, while the probabilistic values are consumed by the optimization and turned into a set of compelling bids. The resulting PoP metric therefore demonstrates the optimization's ability to manage forecast uncertainty as well as measures the forecast's accuracy.

With revenue uplift demonstrating the value of an algorithmic approach and PoP validating performance across software platforms, together these two metrics provide battery asset owners with a clear guide for evaluating algorithmic bidding solutions.

Like revenue uplift, PoP is calculated by comparing the revenues from two scenarios of a year-long backcast:

1. **OPERATIONAL FORESIGHT SCENARIO:**
   The algorithmic bidding solution with an operational forecast (i.e. making real-time trading decisions using Fluence's forecasted prices), and
2. **PERFECT FORESIGHT SCENARIO:**
   The algorithmic bidding solution with perfect foresight (i.e. making real-time trading decisions using actual prices).

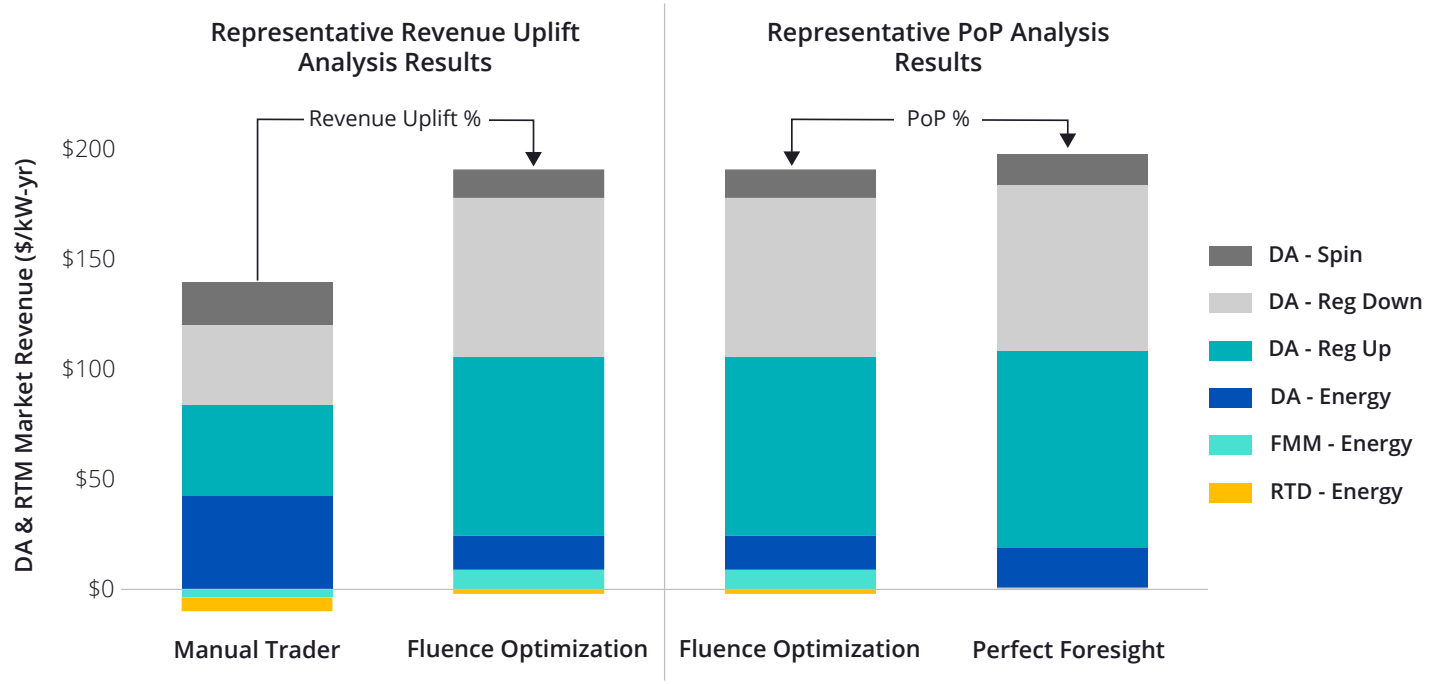
CAISO Case Study

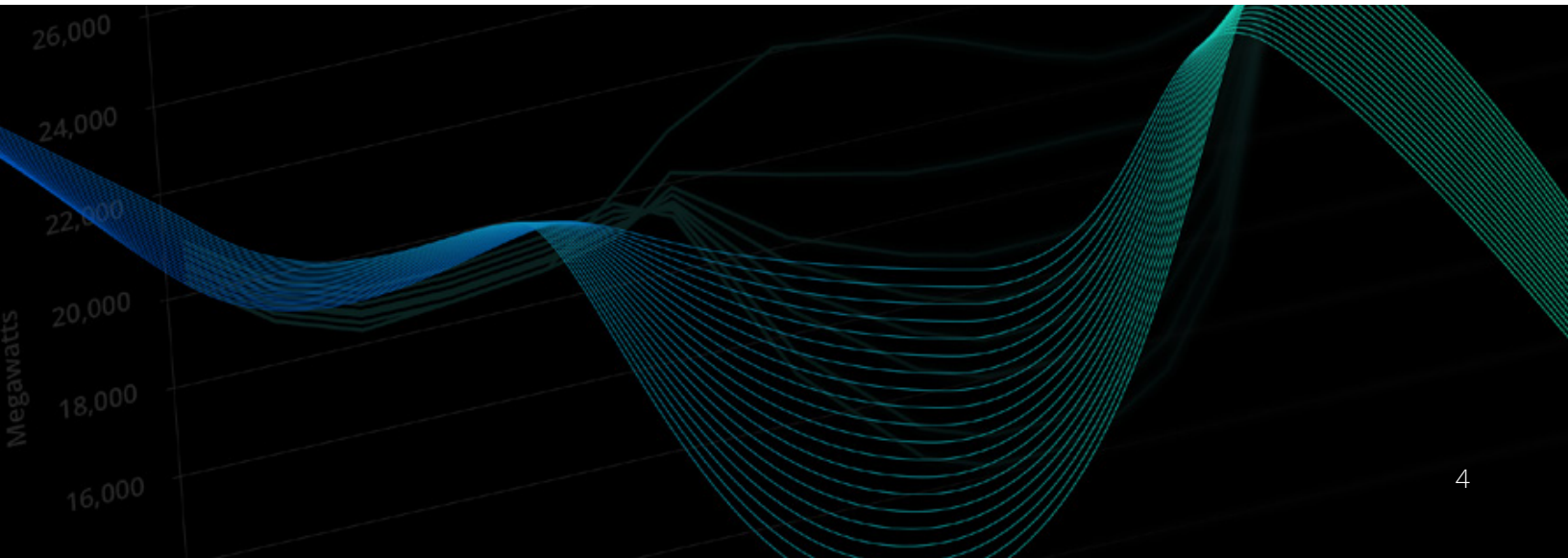
As a provider of algorithmic optimization software, Fluence places great emphasis on its revenue uplift and PoP results. Our analyses of a range of battery assets in California show revenue uplift to be 40-50% compared to a manual bidding strategy and PoP to be 80-95%, with variations driven by asset size and configuration, warranty constraints, and location (i.e., pricing node). Not only does this mean that a 40-50% revenue increase is attainable by employing an algorithmic bidding solution, but also that just 5 -20% of the theoretical maximum market revenue is left unaccounted for when using our powerful algorithmic trading platform.

A visualization like the representative chart below in Figure 2 allows customers to best understand the revenue uplift and PoP analyses results and recognize the revenue impacts across market products.

The Fluence Digital team is constantly evaluating and improving algorithm performance for our assets in CAISO. For more information on Fluence Mosaic, our intelligent bidding software, visit the product webpage here. For additional questions or inquiries regarding site specific analysis of a CAISO storage asset, please contact our team.

FIGURE 2: Example analysis performed with actual 2019 prices. Data includes prices at HAAS_7_B11 price node and NP-15 AS trading zone; 50MW/200MWh; 1 cycle / day limit; 93% charge efficiency and 95% discharge efficiency; regulation up & down cap of 50 MW





About Fluence Mosaic™ for CAISO

Mosaic helps storage asset owners in the California Independent System Operator (CAISO) market capture revenue across energy and ancillary services with bids created every hour.

Maximize storage revenue through advanced forecasting and asset optimization for different markets and products:

CAISO MARKETS

- Day Ahead Market
- Fifteen Minute Market
- Real-Time Dispatch

ENERGY PRODUCTS

- Energy
- Reg Up and Down
- Spin and Non-Spin Reserve

FORECASTING
Advanced machine learning analyzes thousands of variables to predict future market prices every five minutes.

OPTIMIZATION
Advanced co-optimization of all applicable products for day-ahead and real-time markets.

BIDDING
Incorporate your organization's risk tolerance levels with our bidding strategy expertise to prepare ISO-compliant bids for submission.

FLUENCE'S EXPERIENCE

PG&E

Project Snapshot

- Optimization and market bidding services
- 182.4 MW/730 MWh battery storage system
- **Customer:** Pacific Gas and Electric (PG&E)
- **Site:** Moss Landing, CA

Project Overview

- Use advanced price forecasting, portfolio optimization and market bidding algorithms to ensure the system is responding optimally to market and reliability needs in the CAISO wholesale market.
- Provide asset and portfolio managers with updated price forecasts and optimized bids every hour.
- Maximize the value of the asset for PG&E customers, improve grid reliability and efficiency, and support California's transition to a more sustainable and resilient electric grid.

ENDNOTES

1 *https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/battery-storage-passes-biggest-test-yet-in-calif-capacity-crunch-72050380*

2 *CAISO uses the NGR model in order to bid both generation and load sides of battery energy storage systems as a single resource. For more information on CAISO's NGR model, see section 2.1.13 of the Business Process Manual for Market Operations found here: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market%20Operations.*

3 *A backcast is an analysis of what would have occurred over a historical period with known inputs, which in this case are actual energy and ancillary services prices.*

ABOUT FLUENCE

Fluence Energy, Inc. (Nasdaq: FLNC) is a global market leader in energy storage products and services, and cloud-based software for renewables and storage. With industry-leading safety, and cutting-edge technology, Fluence's ecosystem of scalable storage products, comprehensive services, and AI-enabled software help customers drive the clean energy transition.