Ascend
Analytics to Power the Energy Transition

Asset Bid Strategy Optimization
Melding Forecasting with Risk for Live Operations

ESIG

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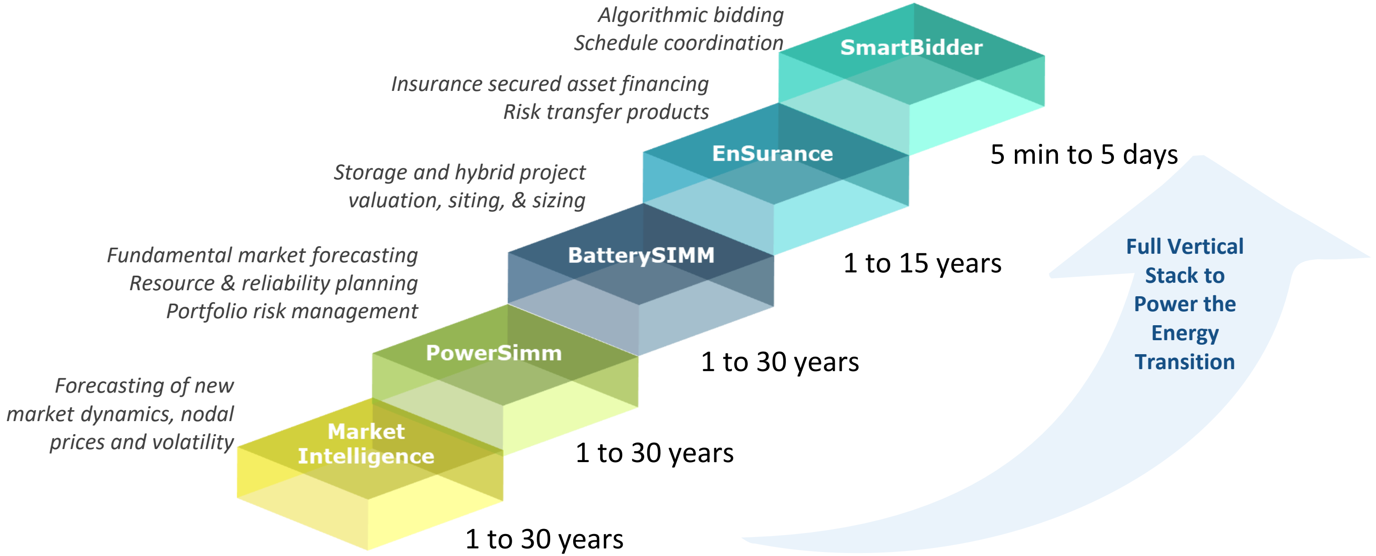
About Ascend Analytics

- Founded in 2002 with 90 employees, 23 PhDs, in Boulder, Oakland, and Bozeman
- Five integrated service lines for operations, portfolio analytics, and planning
- Custom analytical solutions and consulting

Proven & Broadly Adopted

EDF renewables, Duke Energy, NextEra Energy, Terra-Gen, aypa, New York Power Authority, Able Grid, Strata Solar, Los Angeles Department of Water & Power, 8minutenergy, REU Redding Electric Utility, TID Water & Power, nrg, Austin Energy, Ameren, Silicon Valley Clean Energy, BWL, Shell, Glendale Water & Power

Integrated Platform that Builds on Software Components Scalability and Multiple Market Channels

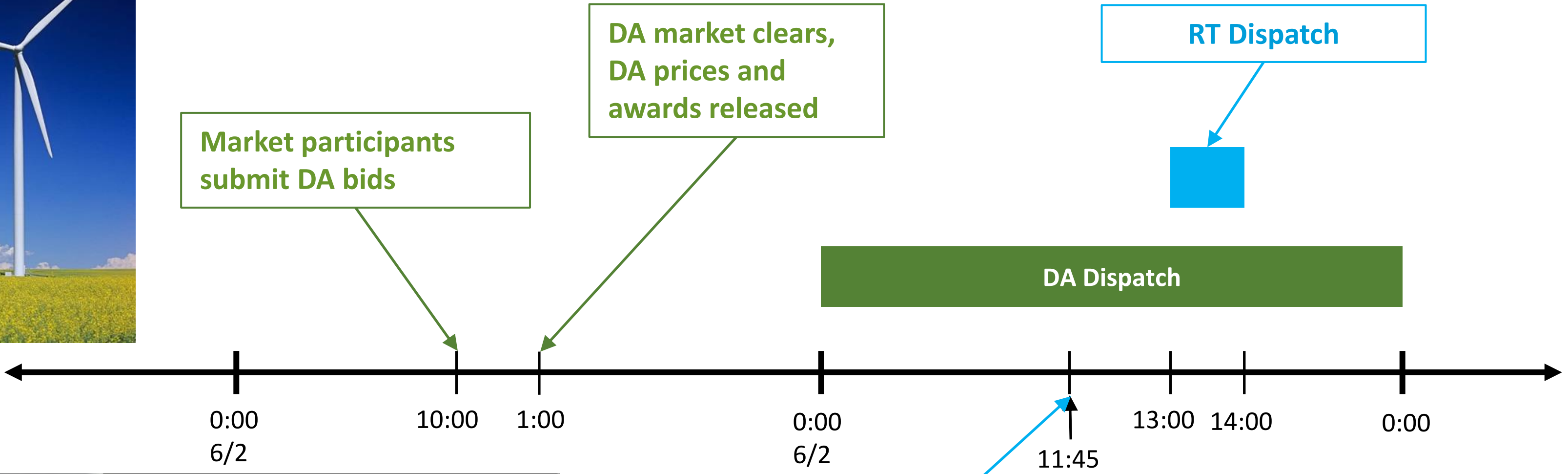


Ascend's Software Platform and Insights Create Value from Investment to Daily Operations

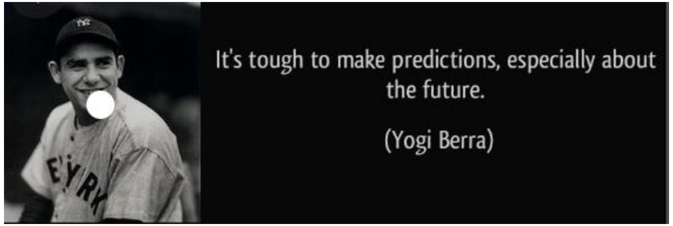
Market Timing:
Day Ahead (DA) and Real-time (RT) Bid Submissions & Dispatch

DA Market Operations
For market day 6/3

RT Market Operations
For market hour HE14 on 6/3



RT bids due 75 minutes in advance of market hour



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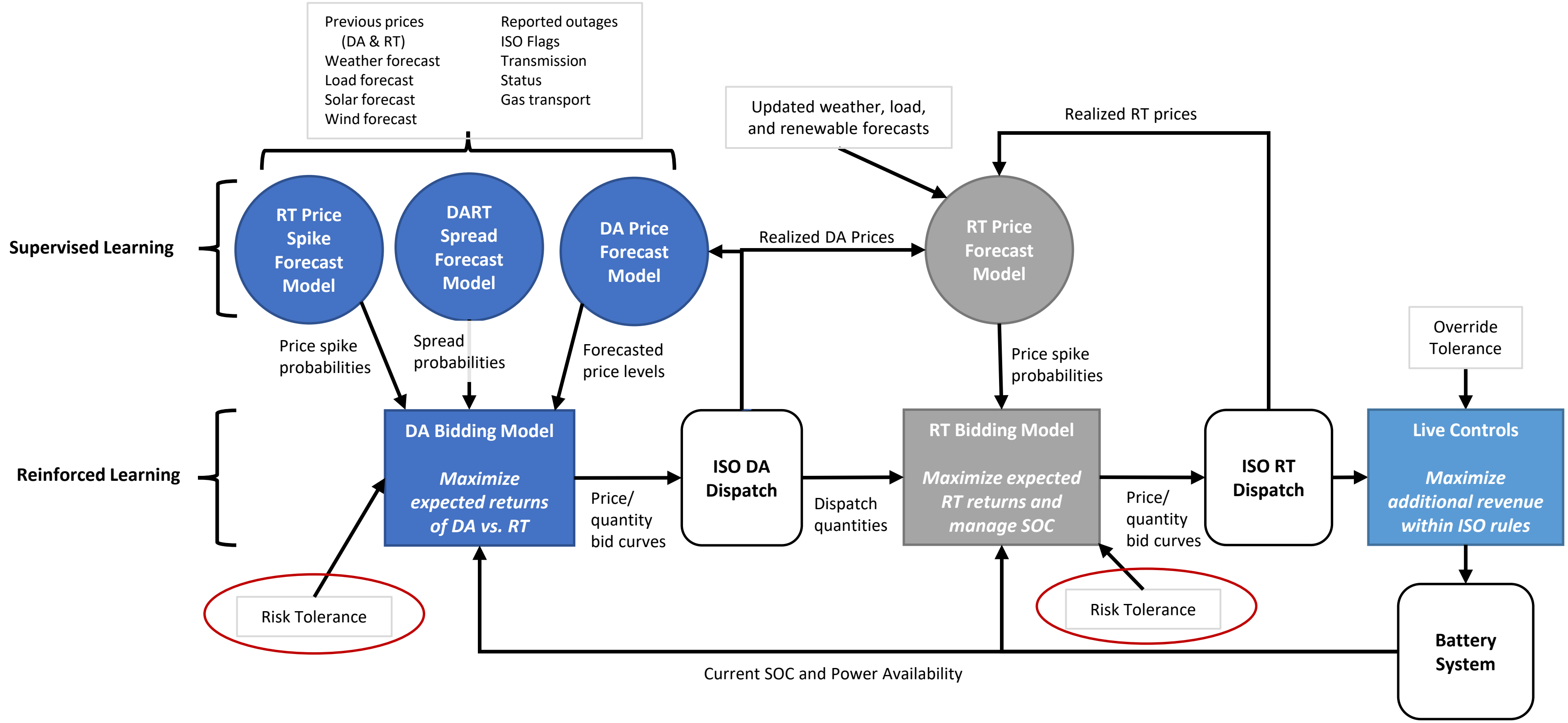
Algorithmic Framework for Optimizing Risk and Reward



Bidding of Wind Generation

Objective Day-ahead:

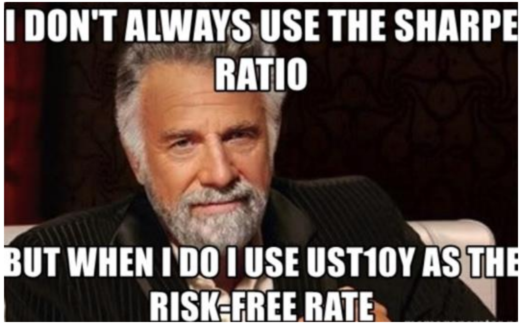
Develop a bidding algorithm for day-ahead (DA) commitments that maximize profits and reduces risk over target strategy. DART = DA-RT price.

$$\max profits \sum_{t \in dau} \mathrm{E}\left[DARTLevel_t\right] * DART\ Probability_t * \mathrm{X}_t^{EnergyBidQ} - \mathrm{X}_t^{DecrementBidQ} \quad \mathrm{E}\left[PriceSpikePrice_t\right] * Probability\ of\ Spike$$

S.T.

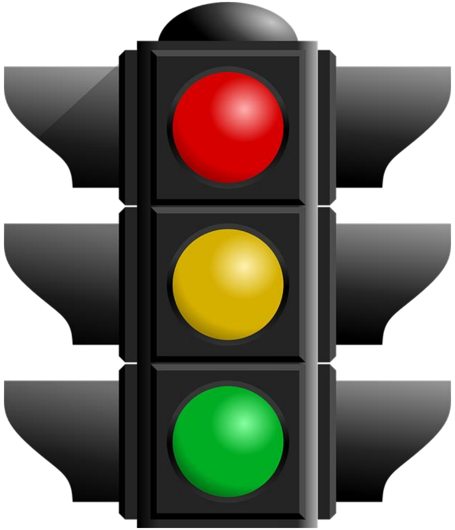
$$\mathrm{X}_t^{DAEnergyBidQ} \leq \mathrm{Q}_t^{Forecast}$$ production constraint

$$Sharpe\ Ratio\ Realized \geq Sharp\ Ratio\ Target$$ risk constraint



Decisions from DART Spreads and Price Spike Probability

$$P_i(DART \geq 0) = .2$$
$$P_i(Spike \geq 100) = .4$$



Go for RT energy!

$$P_i(DART \geq 0) = .8$$
$$P_i(Spike \geq 100) = .05$$

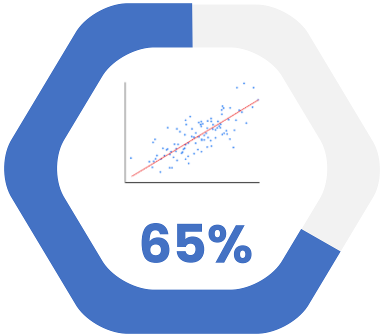
Stick with Day-ahead Energy

How does the probability of a price spike change the guidance?

Probabilistic Forecast

The hybrid model creates probabilistic forecasts with greater forecasting accuracy than machine learning or econometric models alone, translating market events and timeseries patterns into predictive power.

Econometric Model



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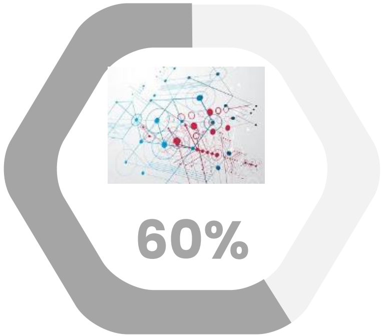
Machine Learning Model



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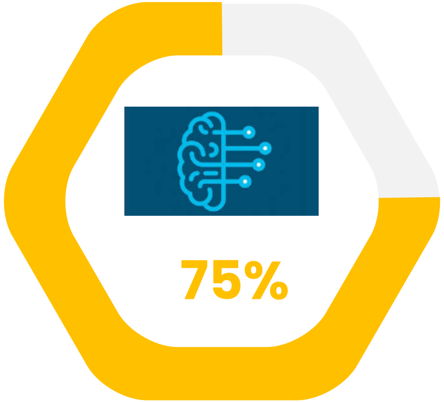
Econometric + Machine Learning Hybrid Model



Forecasting Price Spikes

Objective

- Determine profit maximizing offer of day-ahead offer for energy or ancillaries
  - Day-ahead regulation can be a firm commitment depending on ISO
  - Day ahead commitment precludes realization of real-time price spikes
- Squeeze data to best predict potential for price spikes

Absolute Value vs Probabilistic Value

- Forecasting absolute prices on five-minute intervals in both day-ahead and hour-ahead markets:
  - Mis-specifies the model to the decision analytic. Decision is to maximize expected returns
  - Absolute price forecast leave has significantly less predictive power than probabilistic forecasting. Loss of predictive information.
  - Forecast the probability of spikes best addresses binary offer decision: a) regulation or b) reserve for real-time market

Price Spike Process

- $y_i = \widehat{P}_i = \frac{r_i}{n_i} = X_i'\beta + e$, where “r” is price spikes, and “n” = time periods
  - Price spikes are a function of regressors “X” and error term “e”
- $P\{Price\ Spike\} = X_i'\beta$ (linear regression)
  - Using a Linear probability model: $E[y_i] = P_i$
- $Var[e_i] = \frac{P_i(1-P_i)}{n}$
  - The variance of the error term is a function of the probability of price spikes and the number of time periods

Estimating Price Spikes

- Logistic function:

$$f(\theta) = \frac{e^{\theta}}{1+e^{\theta}}, \text{ where } -\infty < \theta < \infty, \text{ and } 0 < f(\theta) < 1$$

- Logistic function is easy to use due to having a closed form

$$P_i = \frac{1}{1+e^{-I_i}} \text{ for } I_i = X_i'\beta \qquad \frac{P_i}{1-P_i} = e^{I_i} \text{ where } -\infty < I_i < \infty$$

$$\boldsymbol{y_i = ln\left[\frac{P_i}{1-P_i}\right] = X'\beta + e_i^*} \qquad \ln\left[\frac{P_i}{1-P_i}\right] = I_i = X_i'\beta$$

$$\boldsymbol{y_i = X_i'\beta + \frac{e_i}{P_i(1-P_{i)}}}$$

- Price spikes are estimated through the following three step procedure, using the above equations for step 1

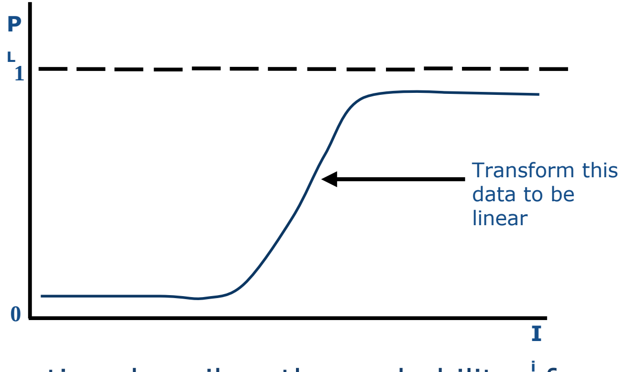
  Three step process

  1. Run OLS, despite heteroskedasticity, to obtain $\widehat{P}_i$ estimates
  2. Predict $\widehat{P}_i \rightarrow \widehat{\widehat{P}}_i$
  3. Plug $\widehat{\widehat{P}}_i$ into Var$[e_i]$ to preform Feasible Generalized Least Squares Estimation

Log Likelihood Function

$$L = \prod_{i=1} \frac{e^{X_i\beta}}{1+e^{X_i\beta}} \prod_{j=1} \frac{1}{1+e^{X_i\beta}},$$

Where 'i' = spike & 'j' = no spike



- Likelihood function describes the probability of a price spike as a function of I_i

Day-Ahead and Real-time Bidding of Renewables in ERCOT

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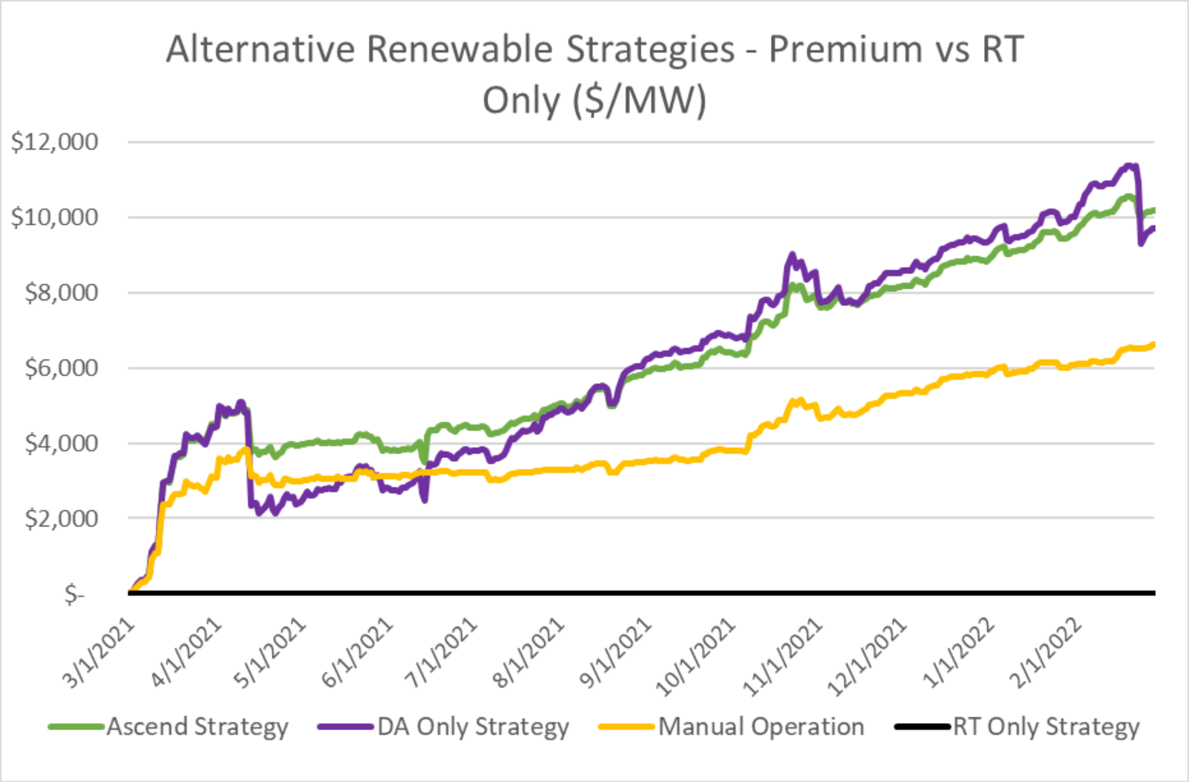
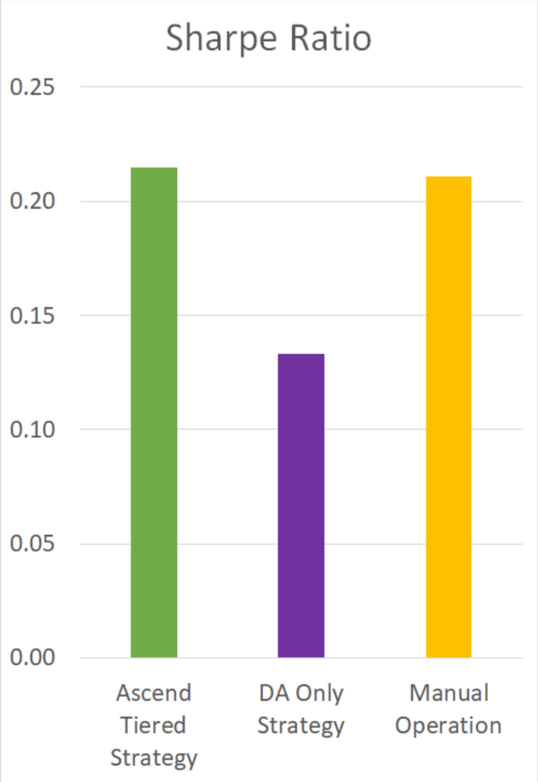
Better models. Better decisions.

Renewable and Projects Optimize Revenue and Minimize Risk by Bidding Renewable Generation in Tiered Bids





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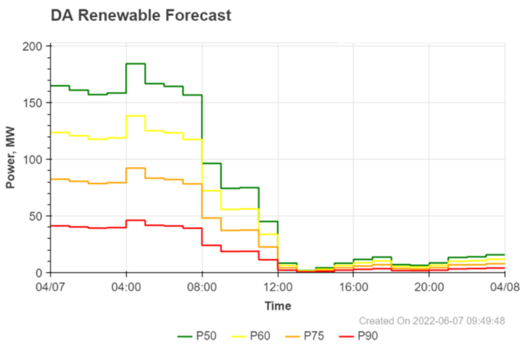
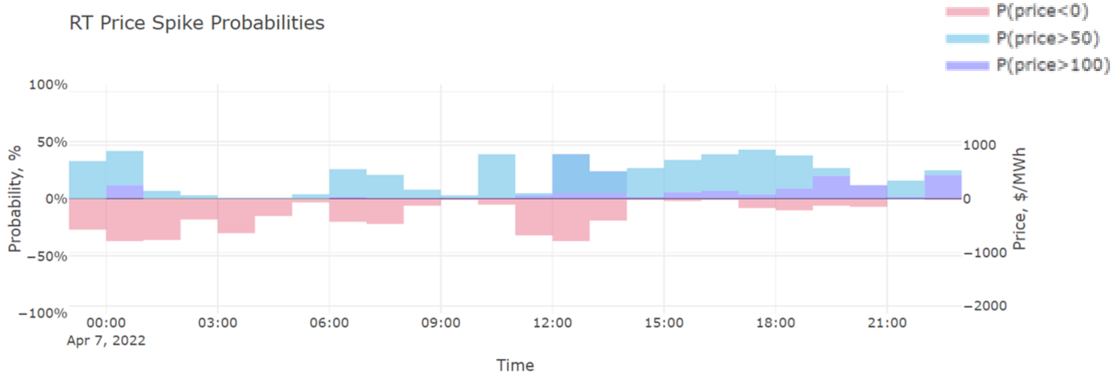
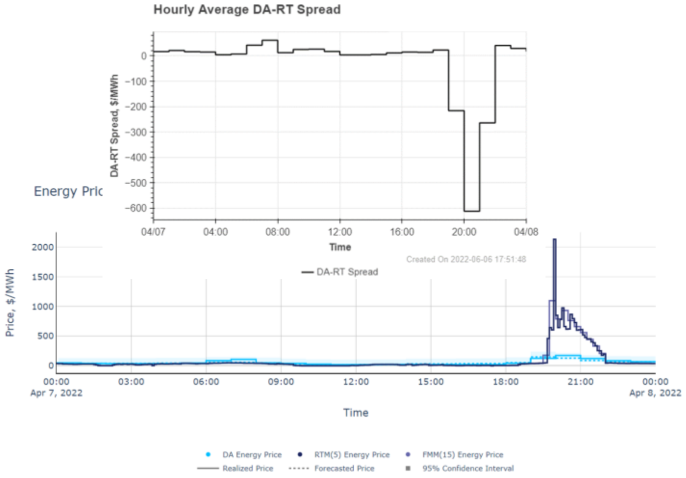
Time series example:
Managing the risk of RT Volatility & Wind Forecast Error

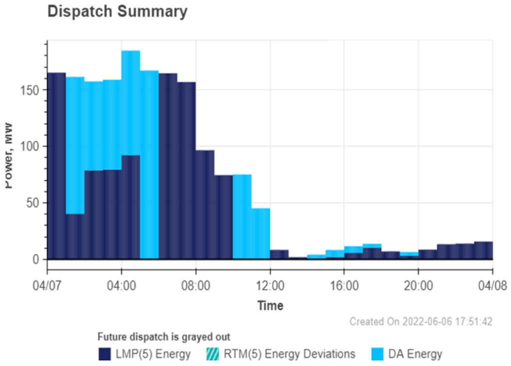
DA Forecasts

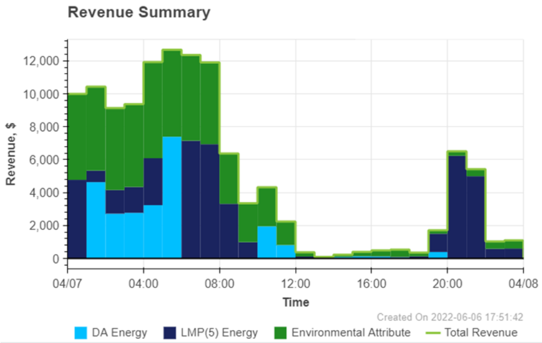




Realized







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Key Take-aways

- The optimal strategy for a given project should take into account both revenue opportunities and the risk profile of different operating choices to fit the goals of the project owner/operator
- Significant opportunities exist for arbitrage between DA and RT energy
- Optimal strategies are tuned for the opportunities that exist in each market

Contact Information

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