

# California Wholesale Electricity Price Forecast

Day-Ahead Market

# Power Economics

- CA's **three investor-owned utilities** have a total market value > **\$72B.** <sup>(1)</sup>
  - PG&E, SDG&E and SCE
  - ~**\$200B** in total assets <sup>(1)</sup>
- Intercontinental Exchange (ICE)
  - ~**\$1B** in energy-related fees in 2018 <sup>(2)</sup>

(1) Yahoo Finance (as of 6/8/20). Includes SDG&E and SCE's parent entities.

(2) Forbes





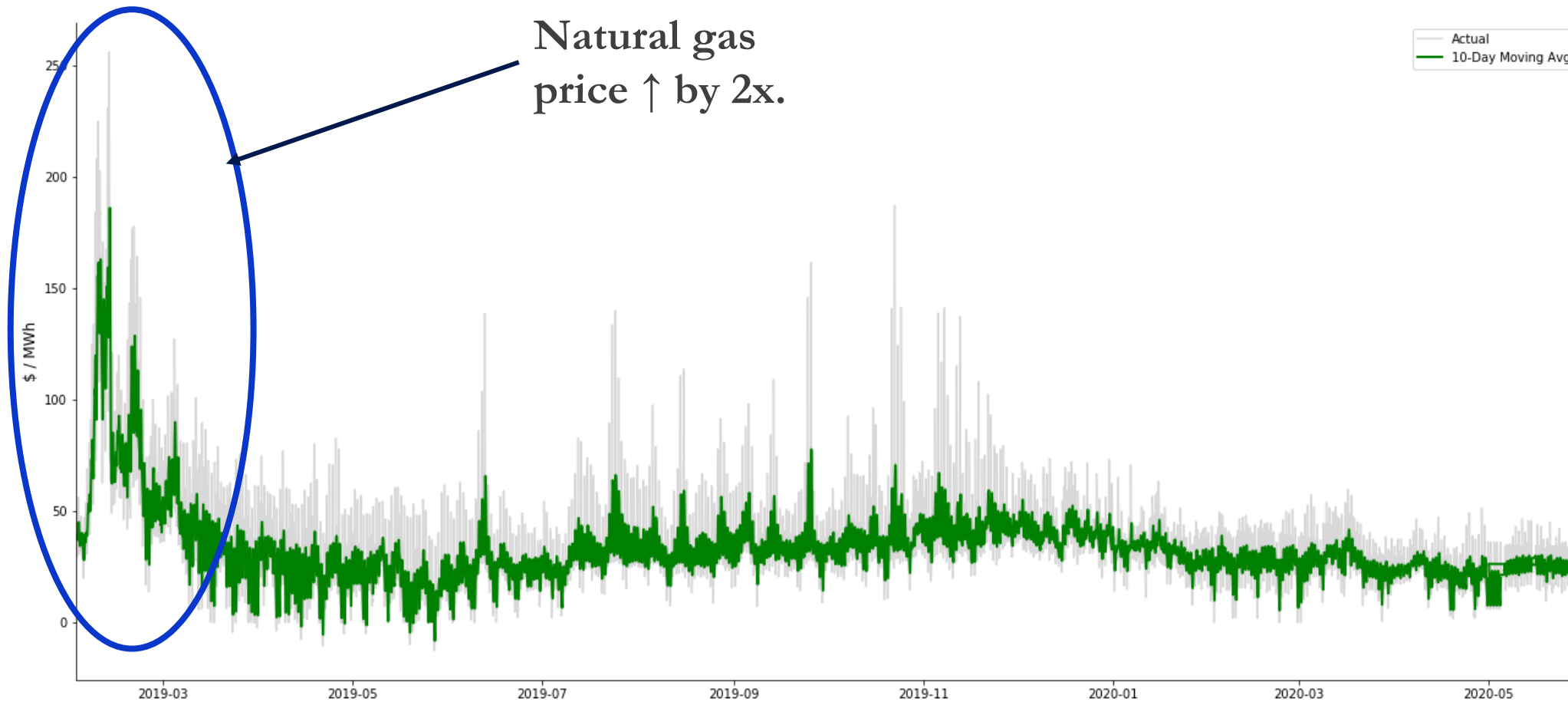
# Data and Preparation

- Three major trading hubs:
  - NP-15, SP-15, and ZP-26
- ~11,500 hours per hub
- March 1, 2019 to May 31, 2020
- CA Energy - CAISO:
  - Generation by resource
  - Consumption
  - Price
- Macroeconomics – FRED
  - Henry Hub natural gas spot price



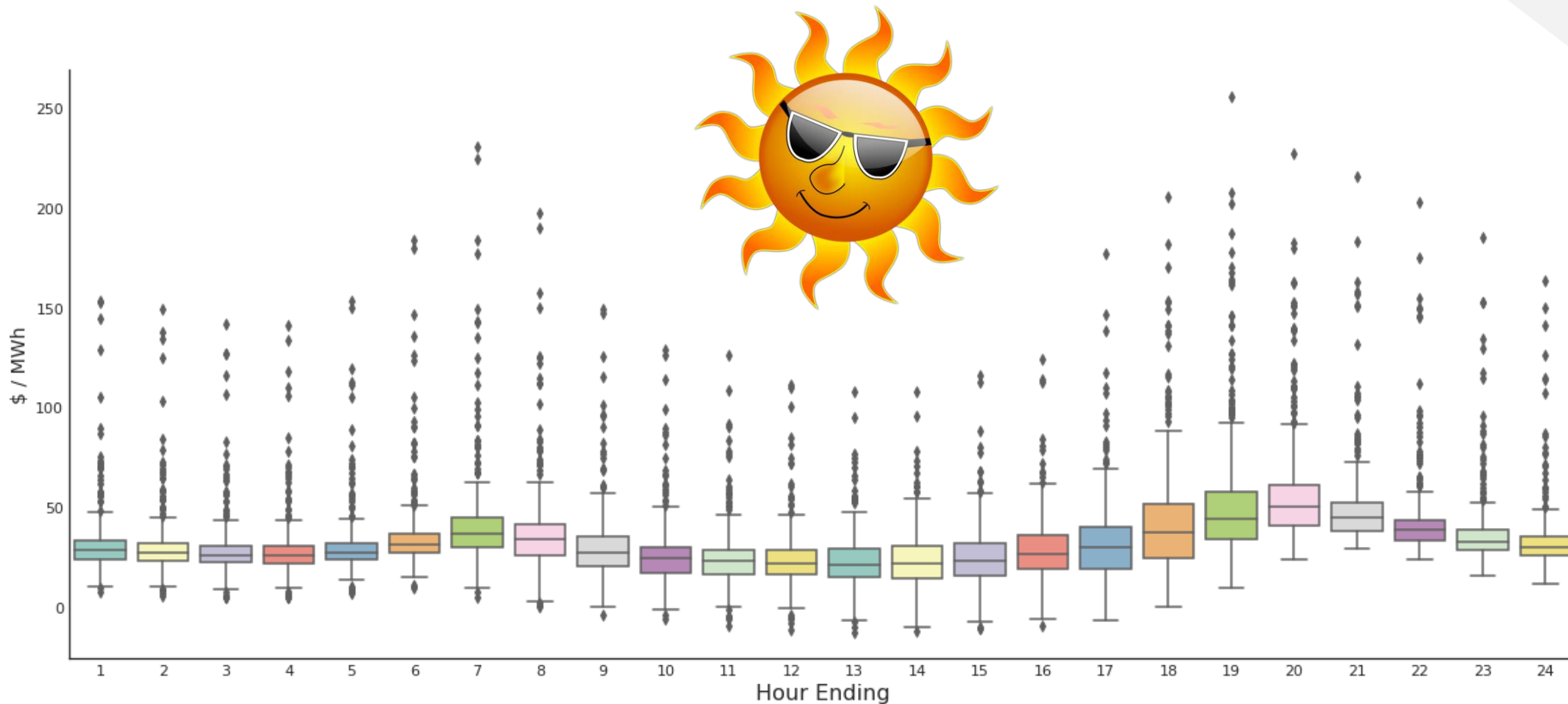
# NP15 (NorCal) Hourly Price

## DAY-AHEAD MARKET



# NP15 (NorCal) Price Distribution

WHAT'S CAUSING THE MID-DAY DIP?





# MODEL EXPERIMENTATION

## 10-DAY HOURLY PRICE FORECAST

### Objective

- Minimize RMSE of hourly prices for 10 days
- All three trading hubs

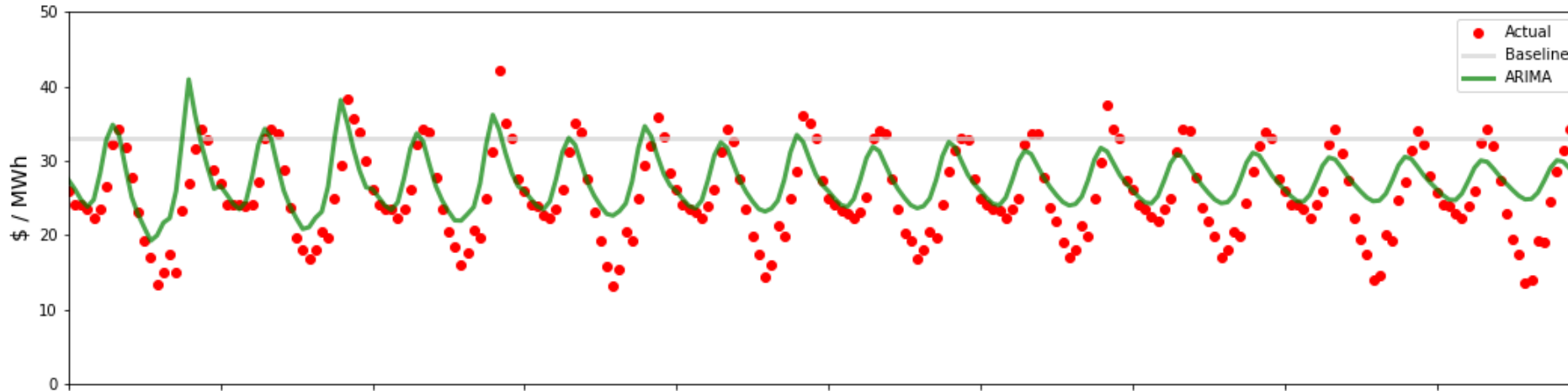
### Key Parameters

- LSTM
  - One hidden layer
  - 32 nodes per layer
  - Batch size = 250
  - # of epochs = 20
- ARIMA
  - Lag order = 24
  - Degree of differencing = 1
  - Order of Moving Average = 0
- Baseline
  - Historic hourly average

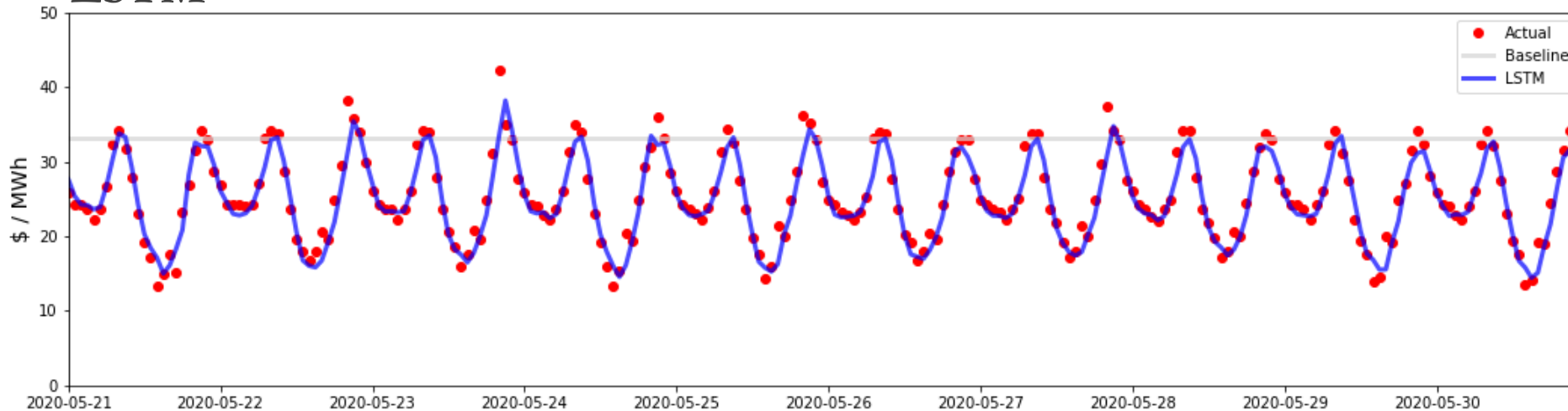
# MODEL COMPARISON

TEN-DAY HOURLY FORECAST – NP15 (NORCAL)

## ARIMA



## LSTM

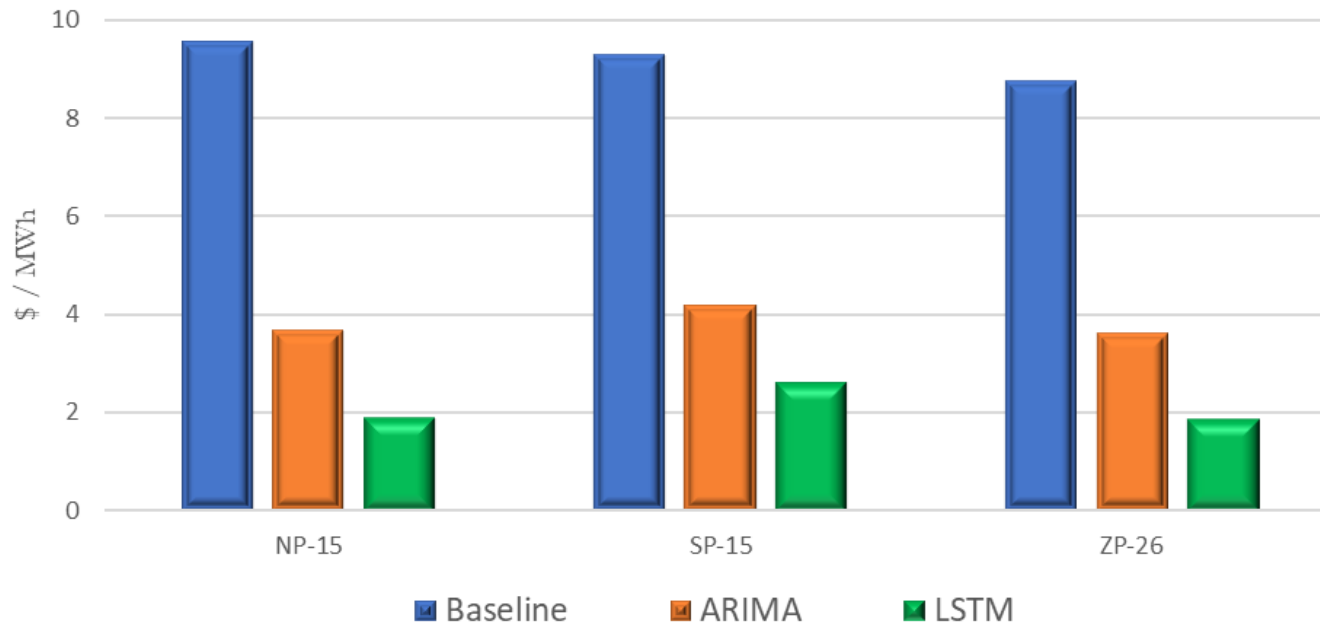




# MODEL RESULTS

## 10-DAY HOURLY PRICE FORECAST

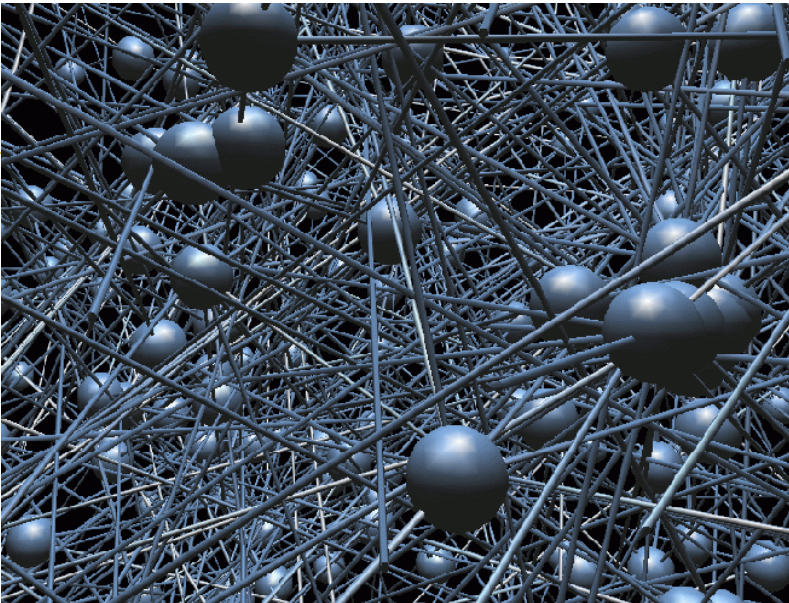
### RMSE



RMSE			
	NP-15	SP-15	ZP-26
Baseline	9.538	9.295	8.752
ARIMA	3.705	4.187	3.645
<b>LSTM</b>	<b>1.901</b>	<b>2.632</b>	<b>1.874</b>

# CONCLUSION

- LSTM is a valuable forecasting method.
  - Retains long-term dependencies
- Simple is effective.
  - LSTM – 1 hidden layer



## Further Exploration

- Multivariate forecasting methods
  - Relationship between exogenous variables and wholesale electricity price
- LSTM to predict energy production and load
  - Grid balancing
  - Reserve requirements



# Thank You



Morgan Sell



[Github Repo](#)



[MorganPSell@gmail.com](mailto:MorganPSell@gmail.com)



443-629-7375