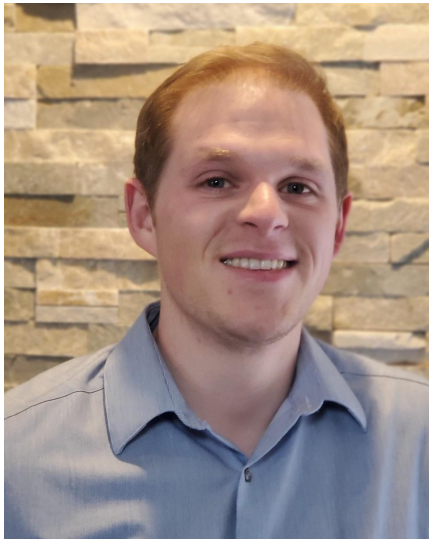
Forecasting Electricity Demand

Analysis and Predictive Modeling

Ryan Blauwaert

About Me

- Originally from Bloomfield Hills, Michigan
- Studied Evolutionary Anthropology and Economics
- Fields of interest include wildlife conservation, energy & resource economics
- Hobbies include:
  - Cooking
  - Soccer
  - Live Music
- Fun Fact: I lived in Southeast Asia for a year



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Motivation

Objective: to accurately forecast electricity demand to facilitate these decisions

Accurately forecasting electricity demand allows companies to:

- Make informed long-term business decisions such as building new power plants in response to increasing demand
- Better allocate resources such as labor from plant to plant
- Start and stop generators in response to anticipated demand
- Adjust load transmission in response to short-term demand fluctuations

Storing electricity for future use is extremely costly and inefficient. Therefore, it is important for electricity producers to generate only as much as is demanded by consumers.

The Data

The U.S. Energy Information Administration provides hourly energy demand data, measured hourly, from across the United States

These records span from July 1, 2015 to the retrieval date

An example of these data can be seen to the right

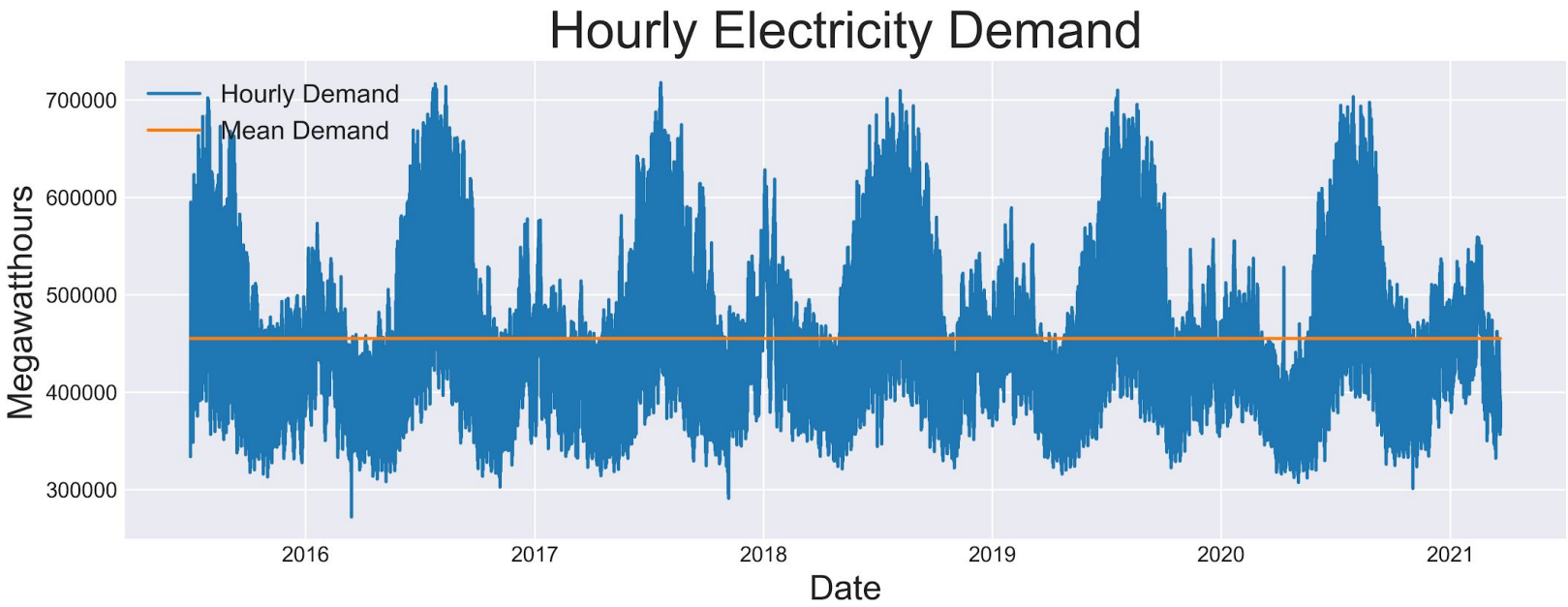
Time	Megawatthours
2015-07-01 02:00:00	335153
2015-07-01 03:00:00	333837
2015-07-01 04:00:00	398386
2015-07-01 05:00:00	388954
2015-07-01 06:00:00	392487

Featurizing the Data

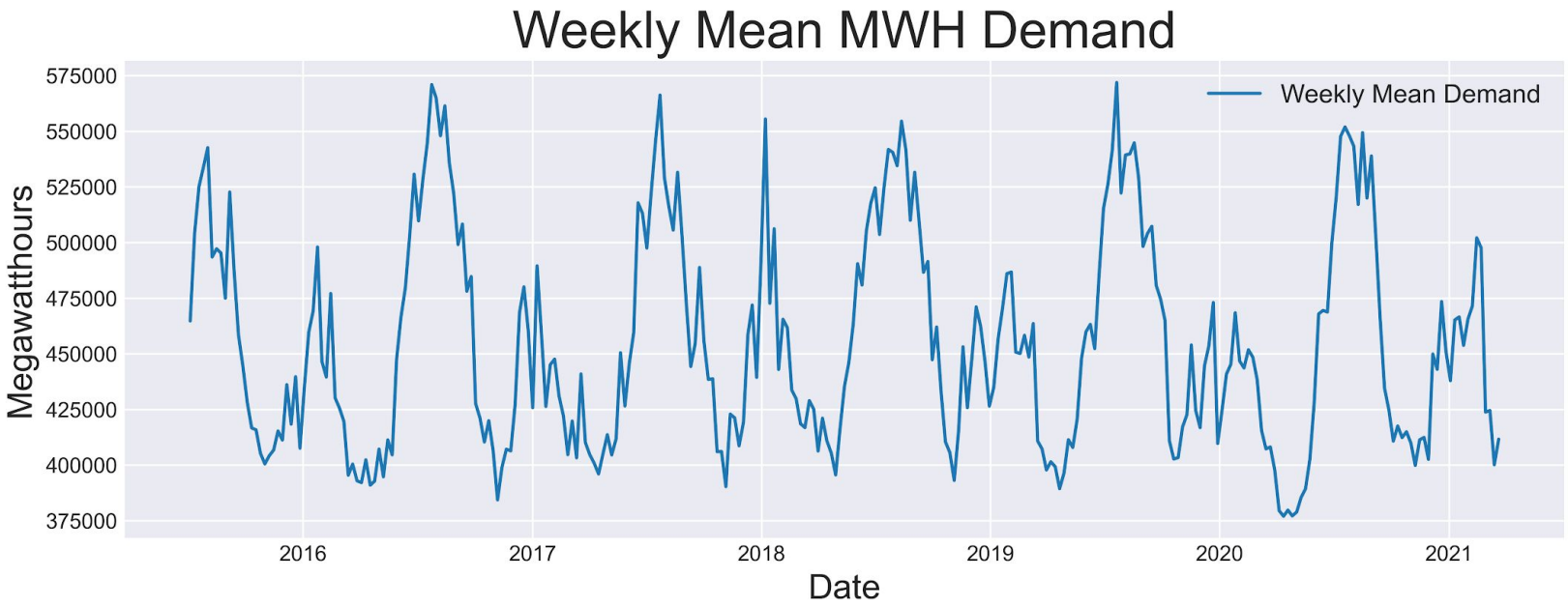
In order to better utilize these data, I created a number of time features as seen below:

Time	Megawatthours	Year	Month	Hour	Day of Week	Day of Month	Day of Year
2015-07-01 02:00:00	335153	2015	7	2	2	1	182
2015-07-01 03:00:00	333837	2015	7	3	2	1	182
2015-07-01 04:00:00	398386	2015	7	4	2	1	182

Visualizing the Data



Visualizing the Data



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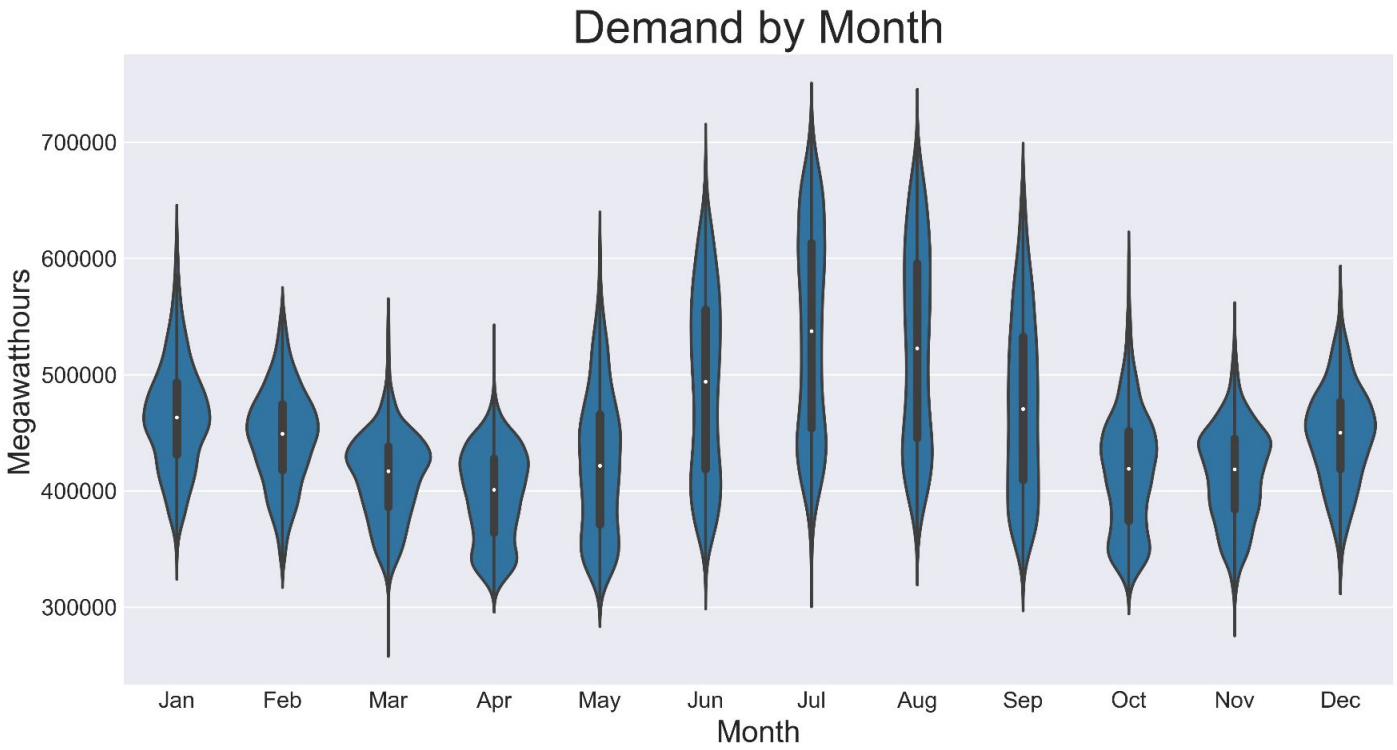
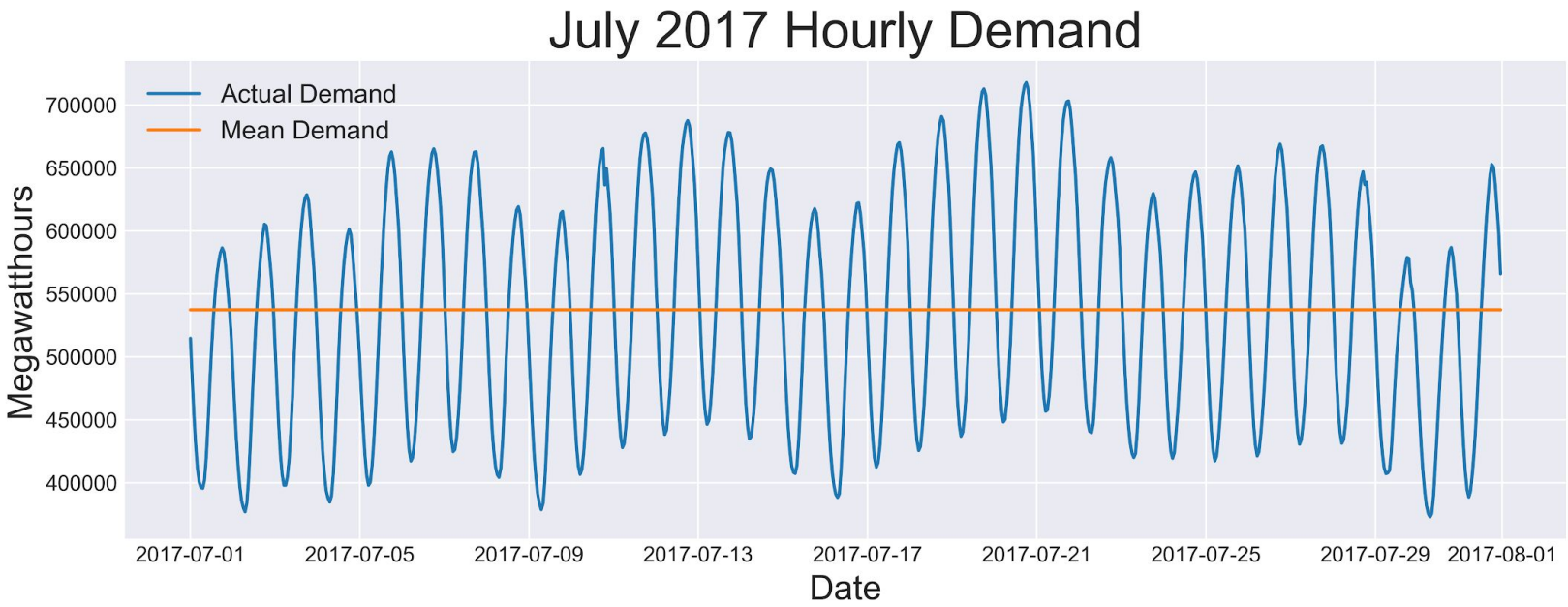
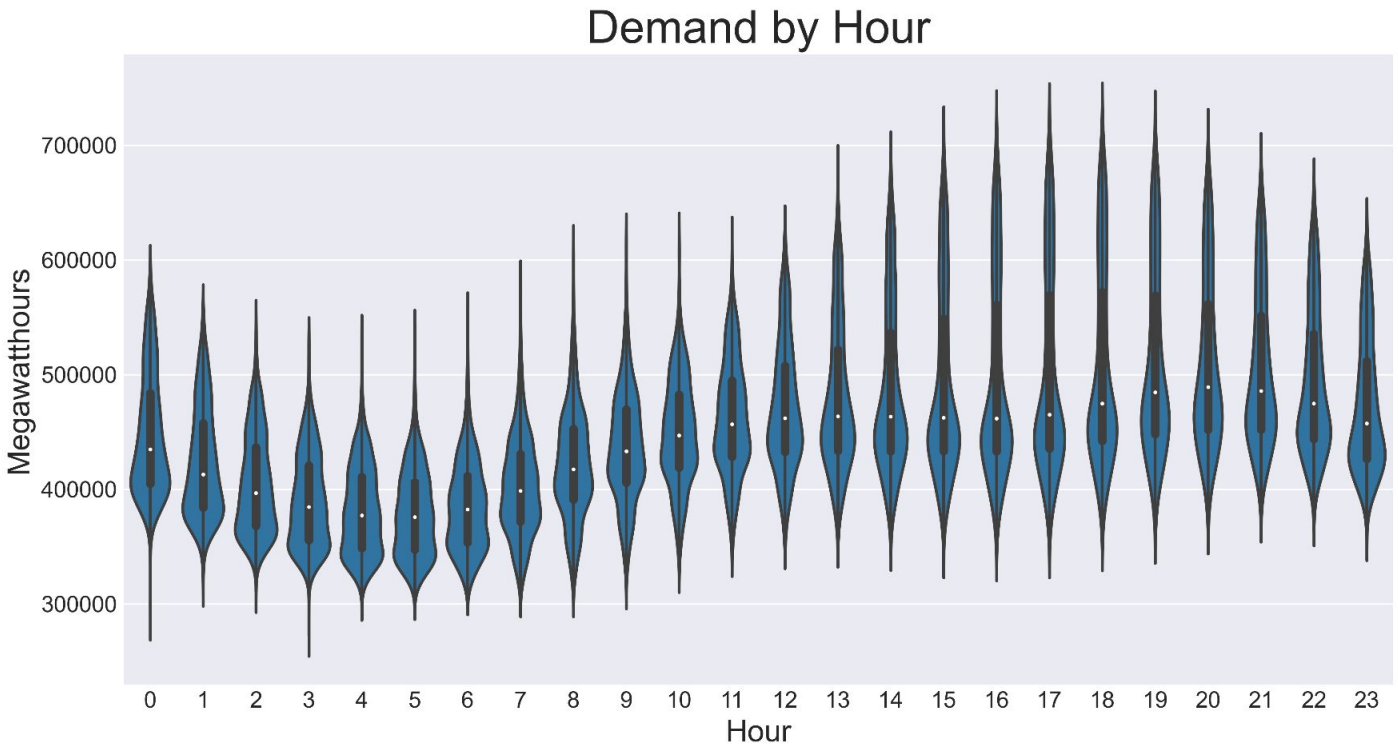


Visualizing the Data



Visualizing the Data



Modeling

Models used:

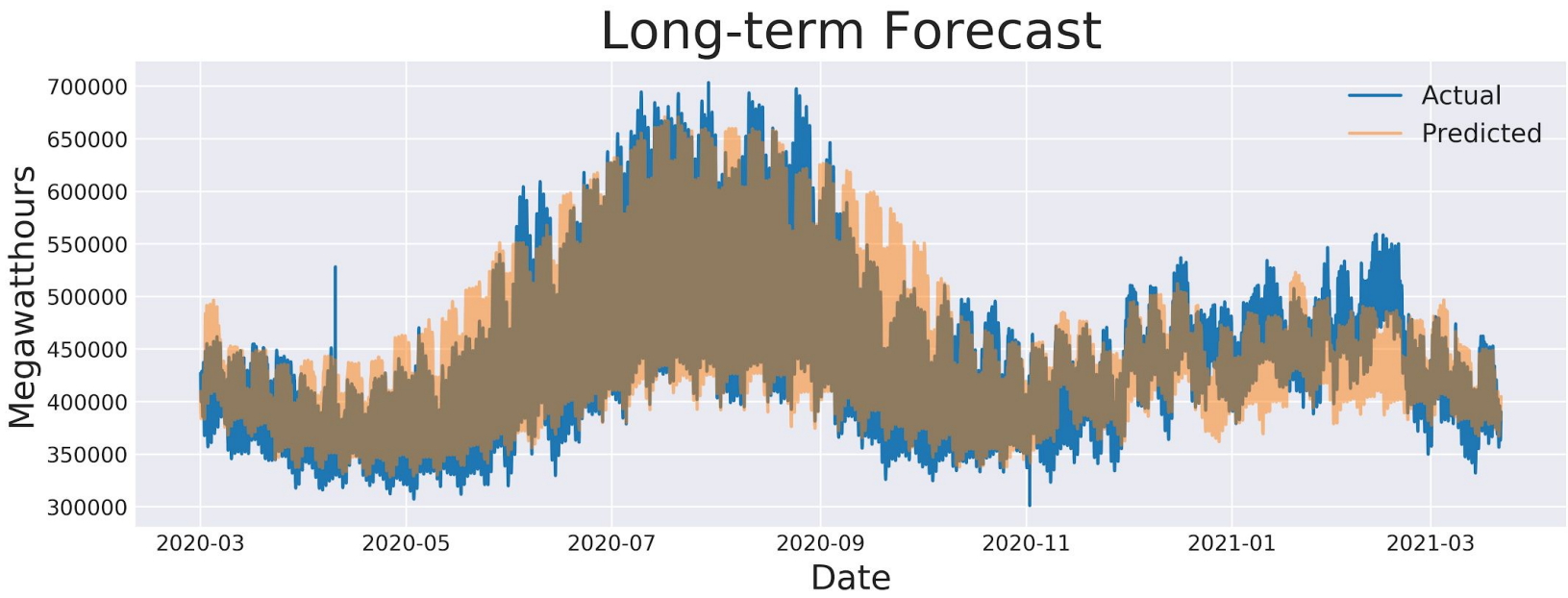
- XGBoost - Gradient Boosting Regressor
- Recurrent Neural Network using various lag metrics

It is important to make note of the error metric used to evaluate the predictions made by the following supervised learning models.

Mean Absolute Percent Error (MAPE) allows us to evaluate error from both over and under-estimation. It is also easily interpretable when working with large numbers.

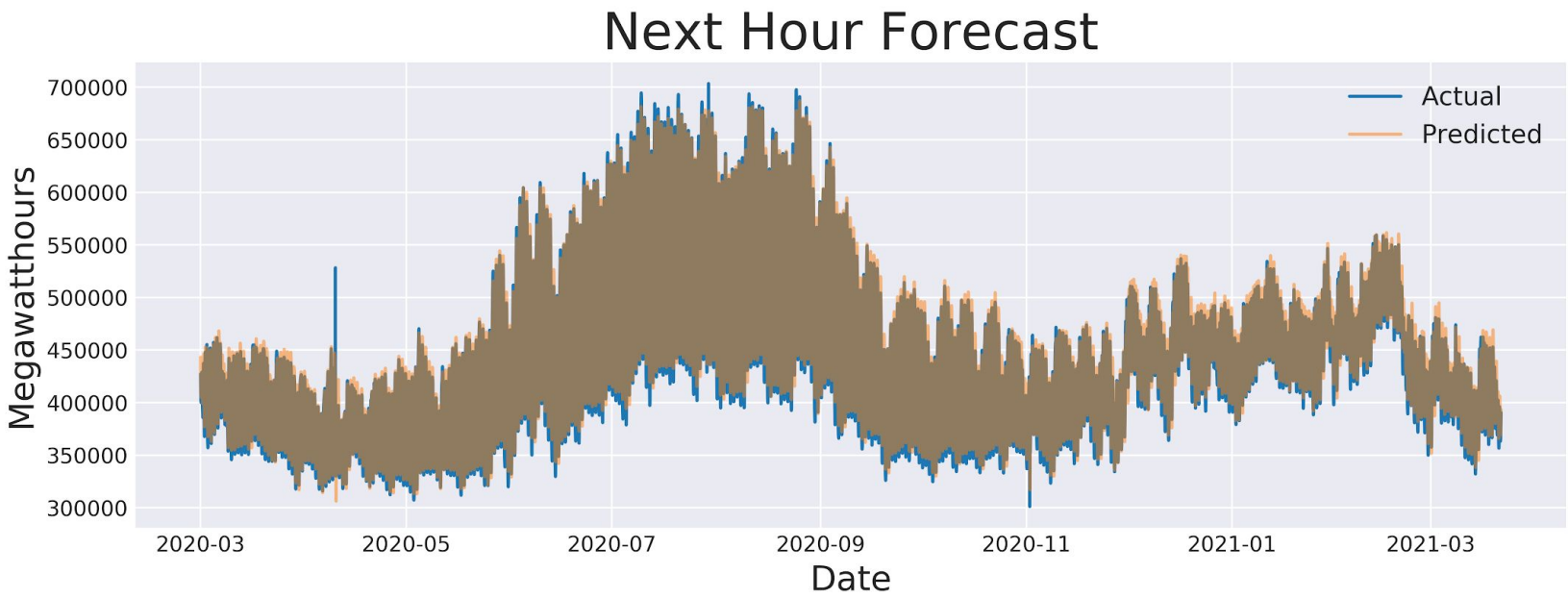
As a point of comparison, the MAPE when predicting using mean electricity demand is 19.3%

XGBoost Model



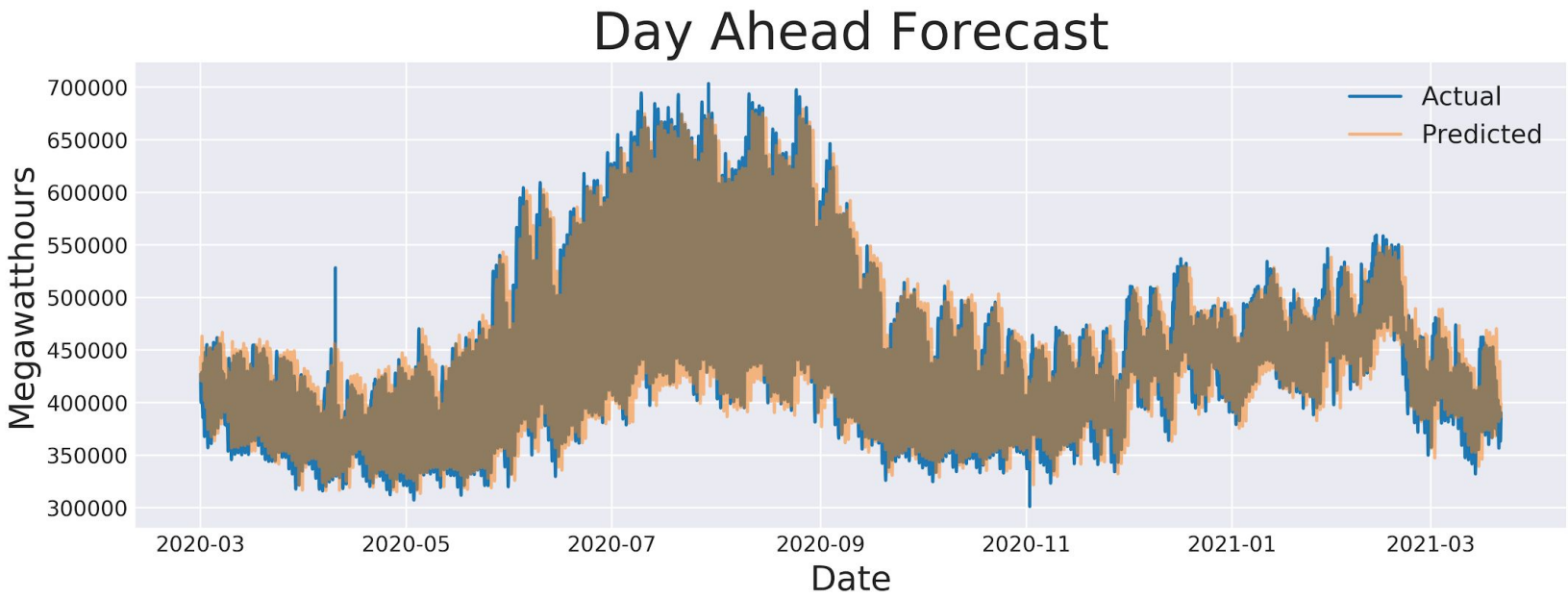
MAPE: 5.0%

RNN Model - Next Hour



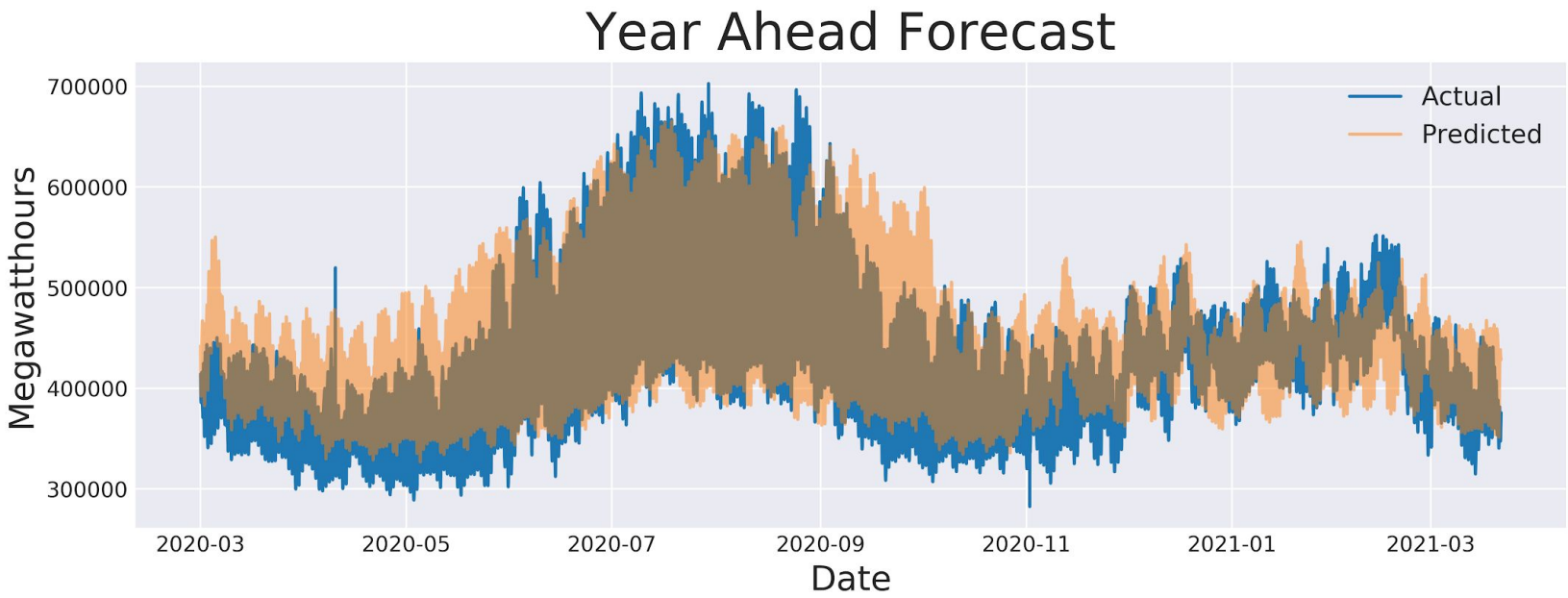
MAPE: 1.9%

RNN Model - 24 Hours Ahead



MAPE: 3.9%

RNN Model - 1 Year Ahead



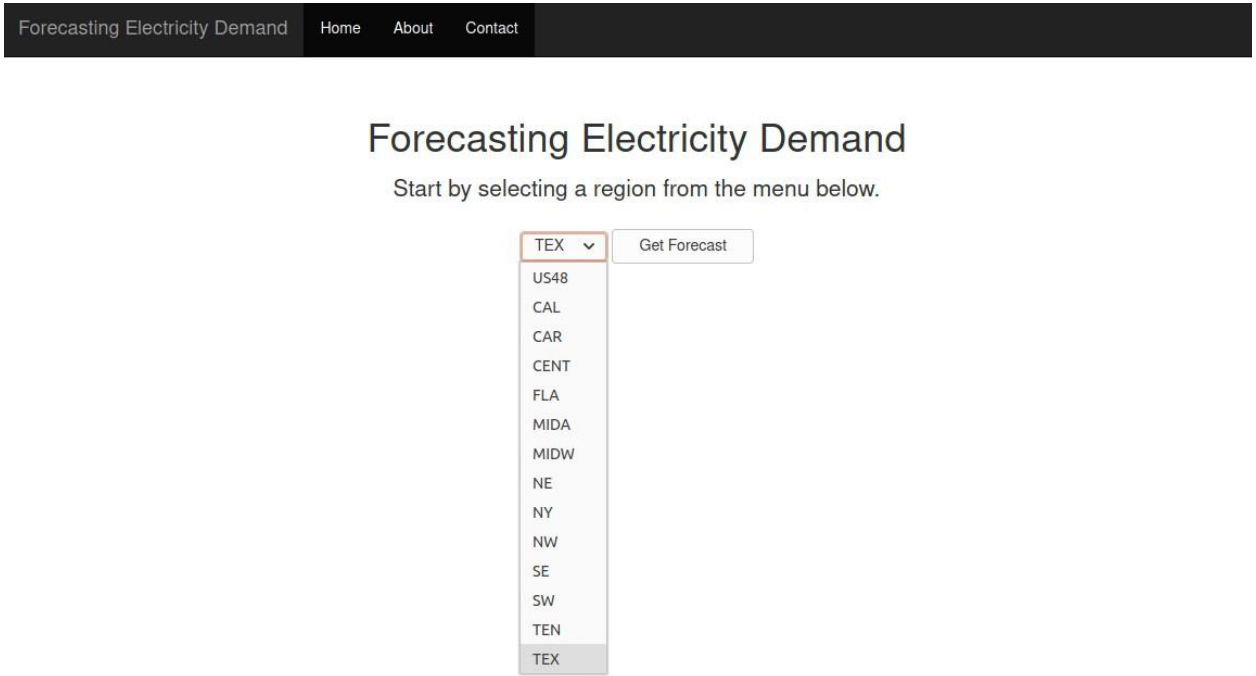
MAPE: 8.9%

Model Performance

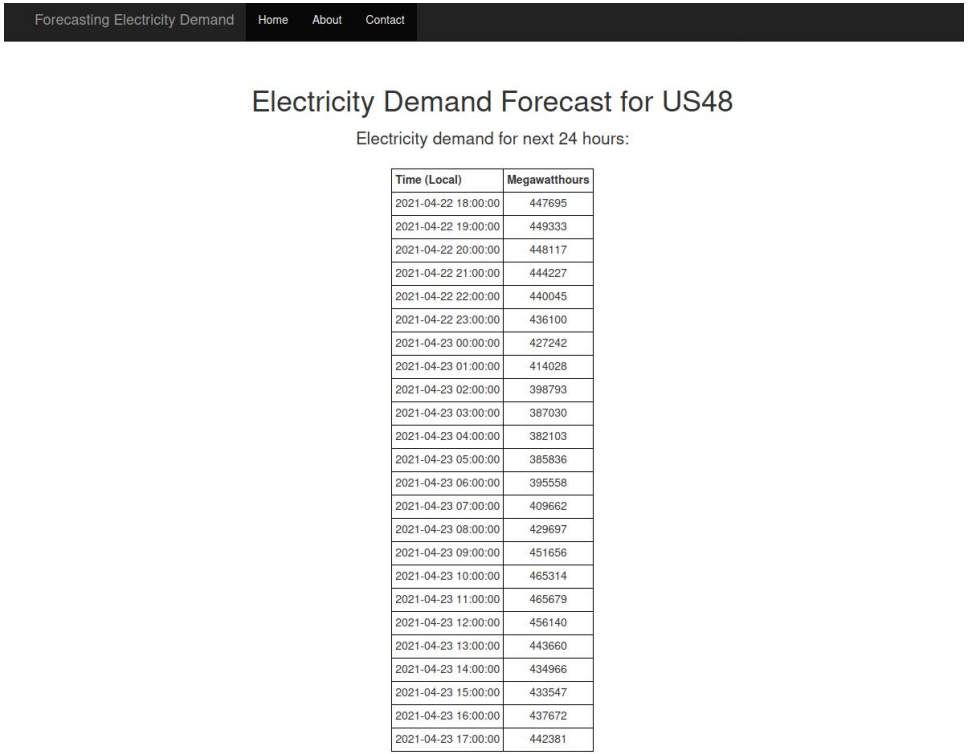
- All tested models outperformed our baseline predictions
- Autoregressive RNN performs best for short-term forecasting
- XGBoost performs best for long-term forecasting

Model	Error
5 Year Mean Prediction	19.3%
Time Feature XGBoost	5.0%
Next Hour RNN 24 Lag Features	1.9%
Day Ahead RNN 24 Lag Features	3.9%
Year Ahead RNN 24 Lag Features	8.9%

Web Application

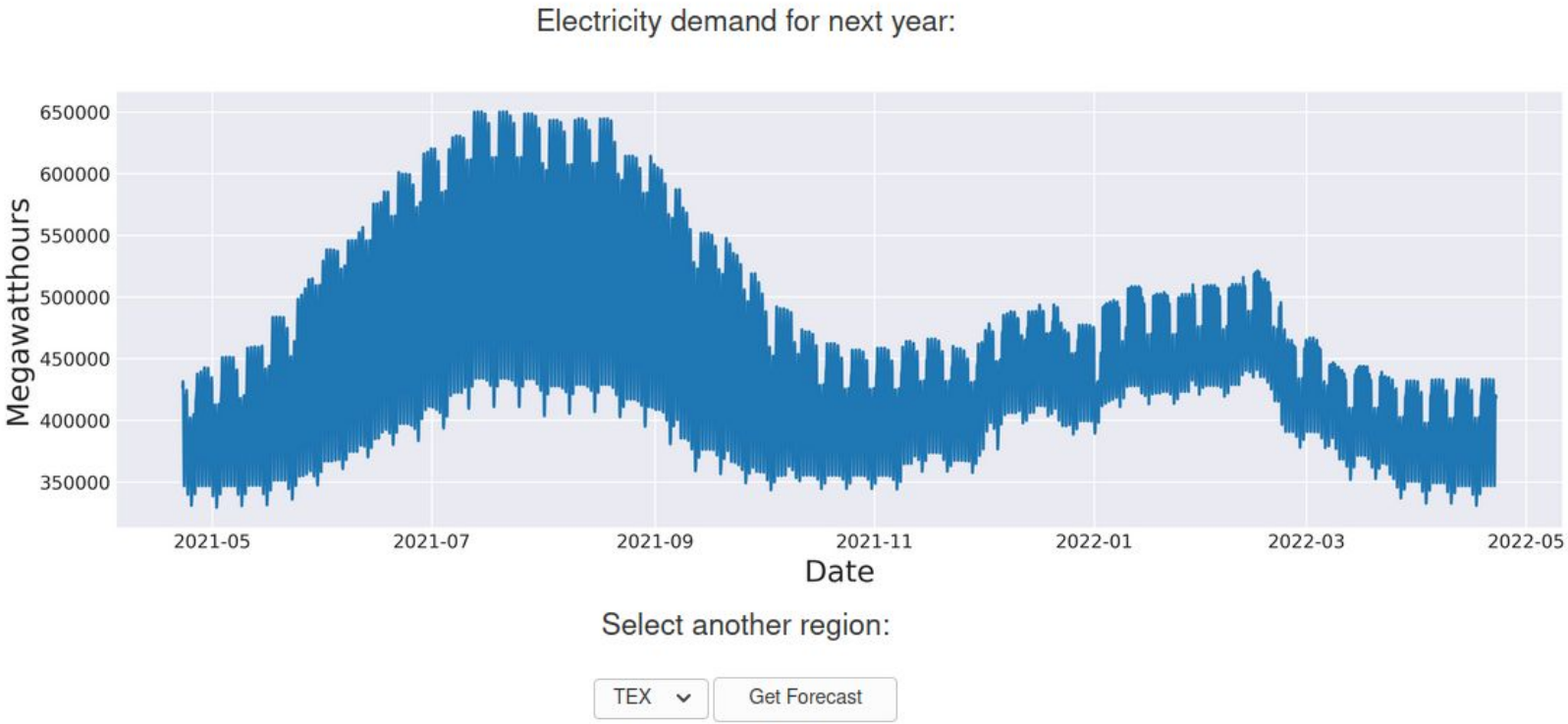


Web Application



Time (Local)	Megawatthours
2021-04-22 18:00:00	447695
2021-04-22 19:00:00	449333
2021-04-22 20:00:00	448117
2021-04-22 21:00:00	444227
2021-04-22 22:00:00	440045
2021-04-22 23:00:00	436100
2021-04-23 00:00:00	427242
2021-04-23 01:00:00	414028
2021-04-23 02:00:00	398793
2021-04-23 03:00:00	387030
2021-04-23 04:00:00	382103
2021-04-23 05:00:00	385836
2021-04-23 06:00:00	395558
2021-04-23 07:00:00	409662
2021-04-23 08:00:00	429697
2021-04-23 09:00:00	451656
2021-04-23 10:00:00	465314
2021-04-23 11:00:00	465679
2021-04-23 12:00:00	456140
2021-04-23 13:00:00	443660
2021-04-23 14:00:00	434966
2021-04-23 15:00:00	433547
2021-04-23 16:00:00	437672
2021-04-23 17:00:00	442381

Web Application



Directions for Further Work

- Incorporation of weather data to capture short-term fluctuations in demand
- Incorporation of additional historical data to assess long-term electricity demand trends
- Additional web application formatting and functionality

Stay Tuned:

- github.com/ryan-blauwaert
- linkedin.com/in/ryanblauwaert