

Impact of Drought on the Energy Sector

NOAA-NIDIS Capstone Project



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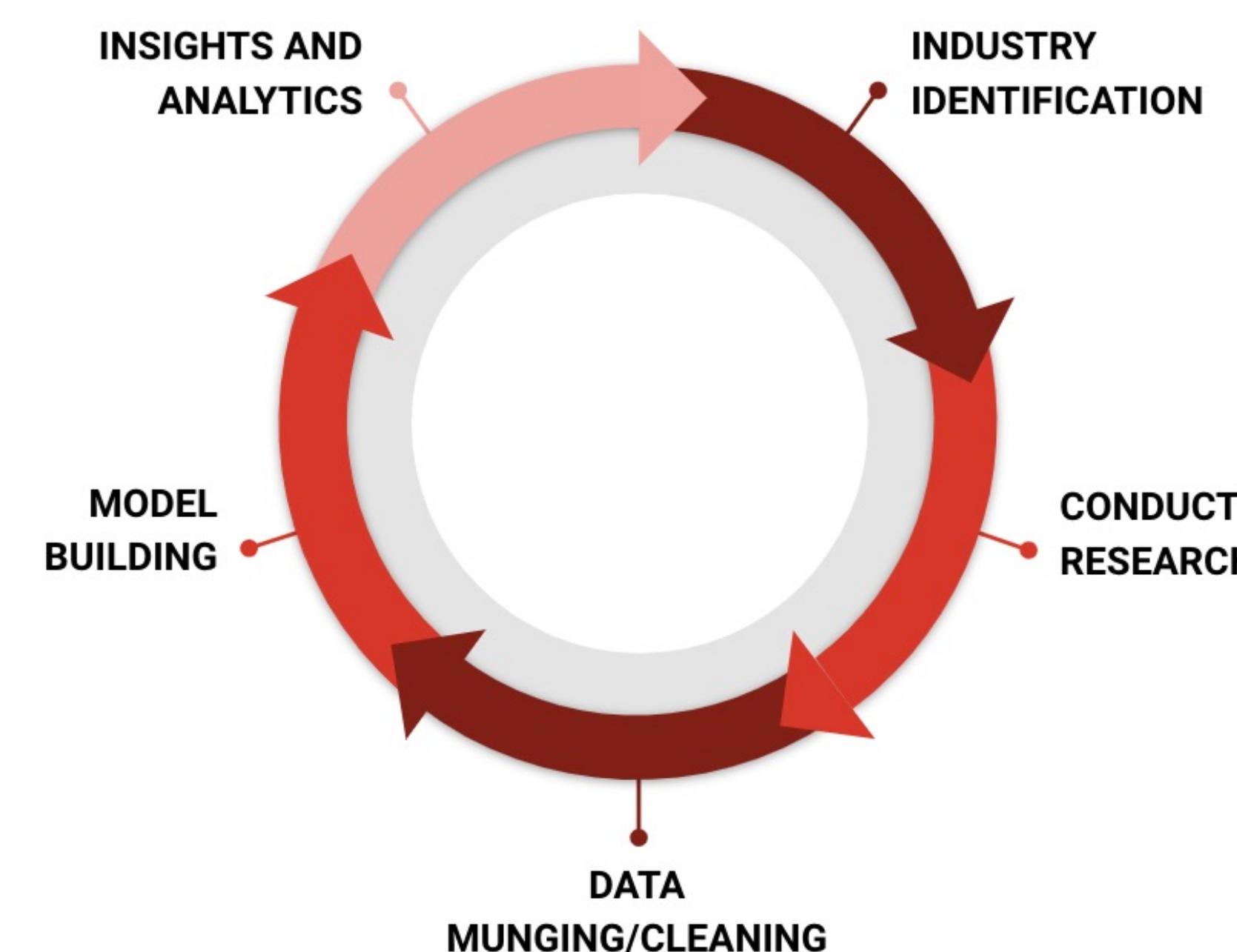
Yapei Xiong

Introduction

Drought has plagued civilization for millennia and with the explosive population growth, it is placing much more pressure on water supplies. Hence, it is crucial to understand the impact of drought on different sectors of the economy with the everyday increase in population. The end goal of this project is to increase the dissemination of energy production variation given certain drought conditions, to the electricity producers in a way that allows them to anticipate changes in the energy prices and demand. The following are the key goals of the project:

- Correlation between drought affecting variables to check the influence of one variable over the other
- Predictive modeling to observe the trends through the years 2011-2020
- A complete database that relates electricity generation and consumption of power plants and water resources
- A front-end dashboard that visualizes trends and descriptive statistics for drought-affecting variables

Methodology



Data Collection and Analysis

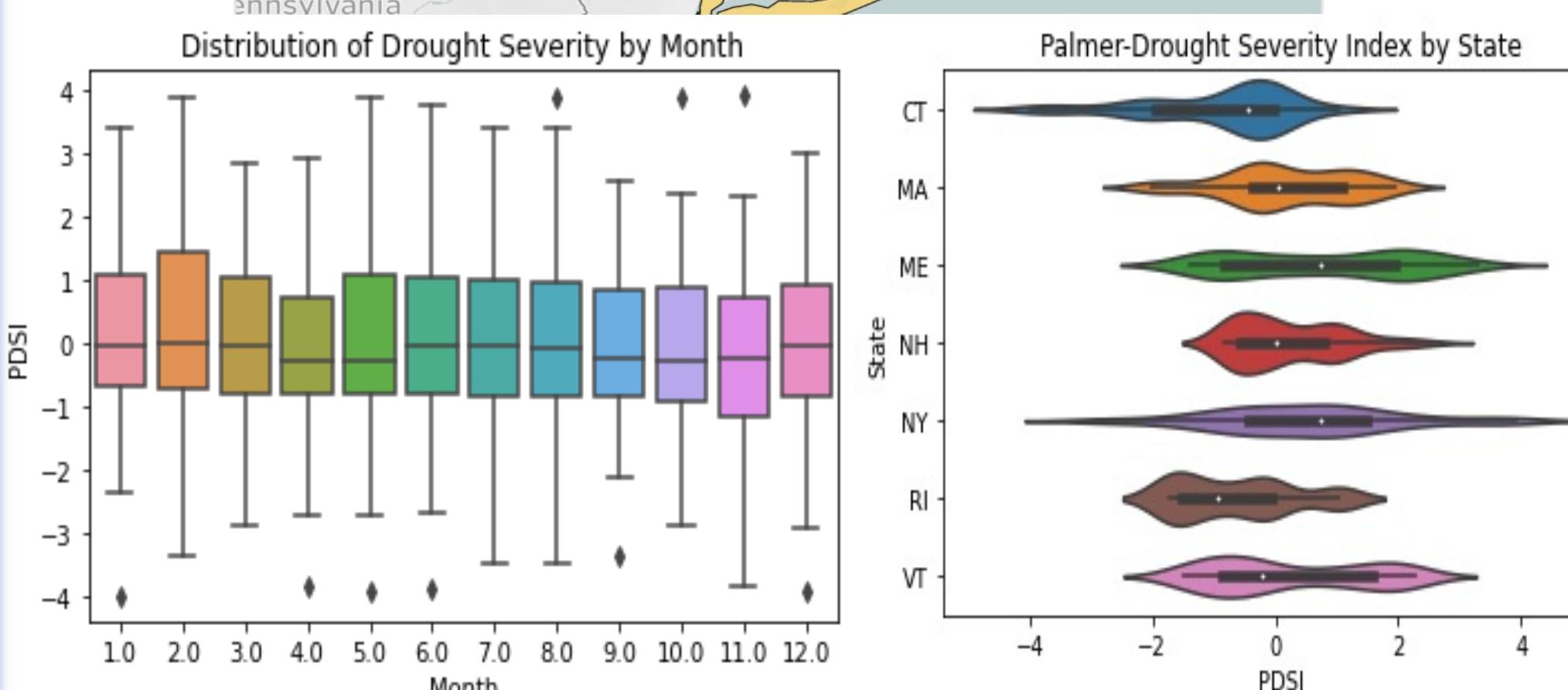
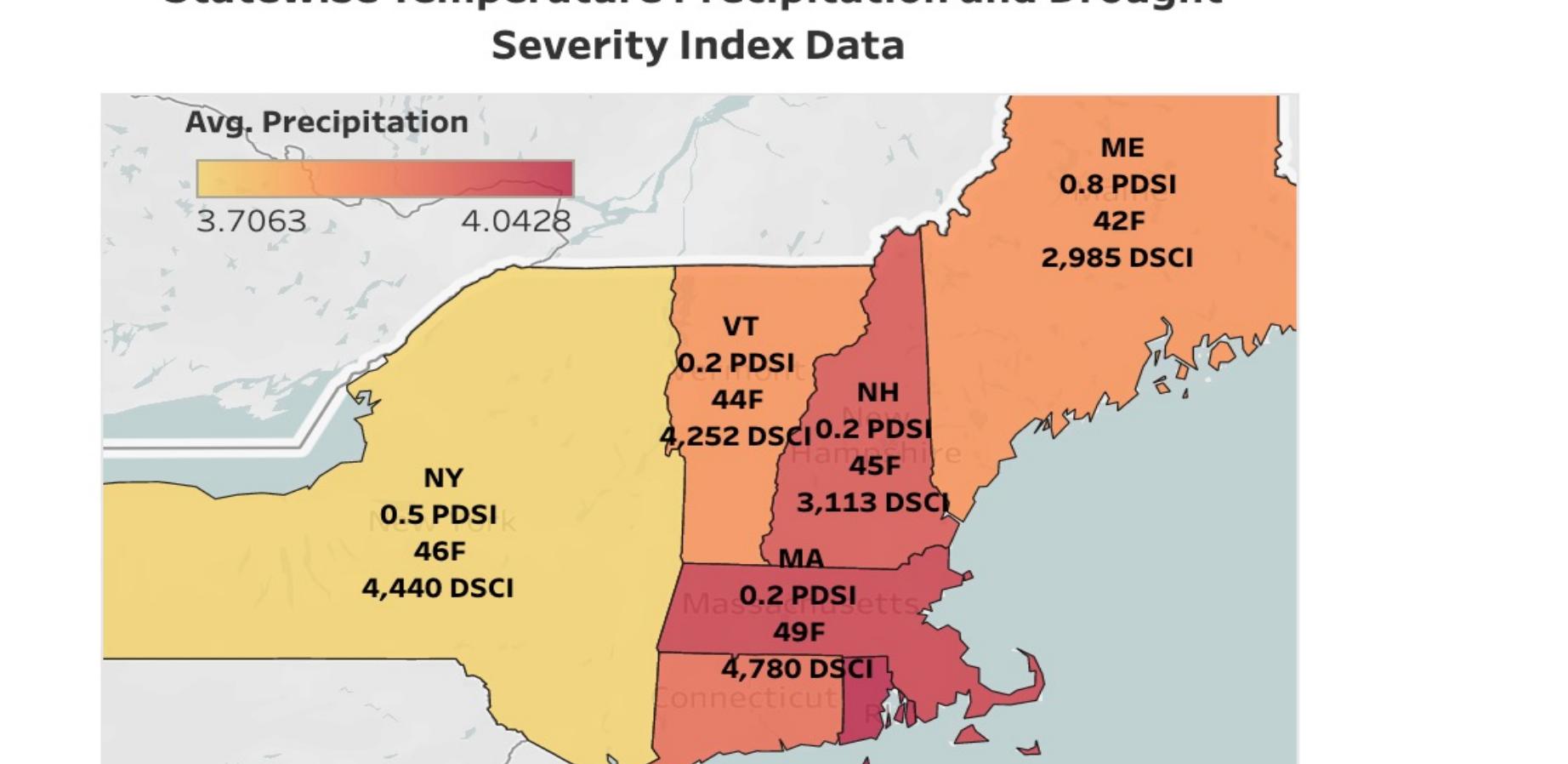
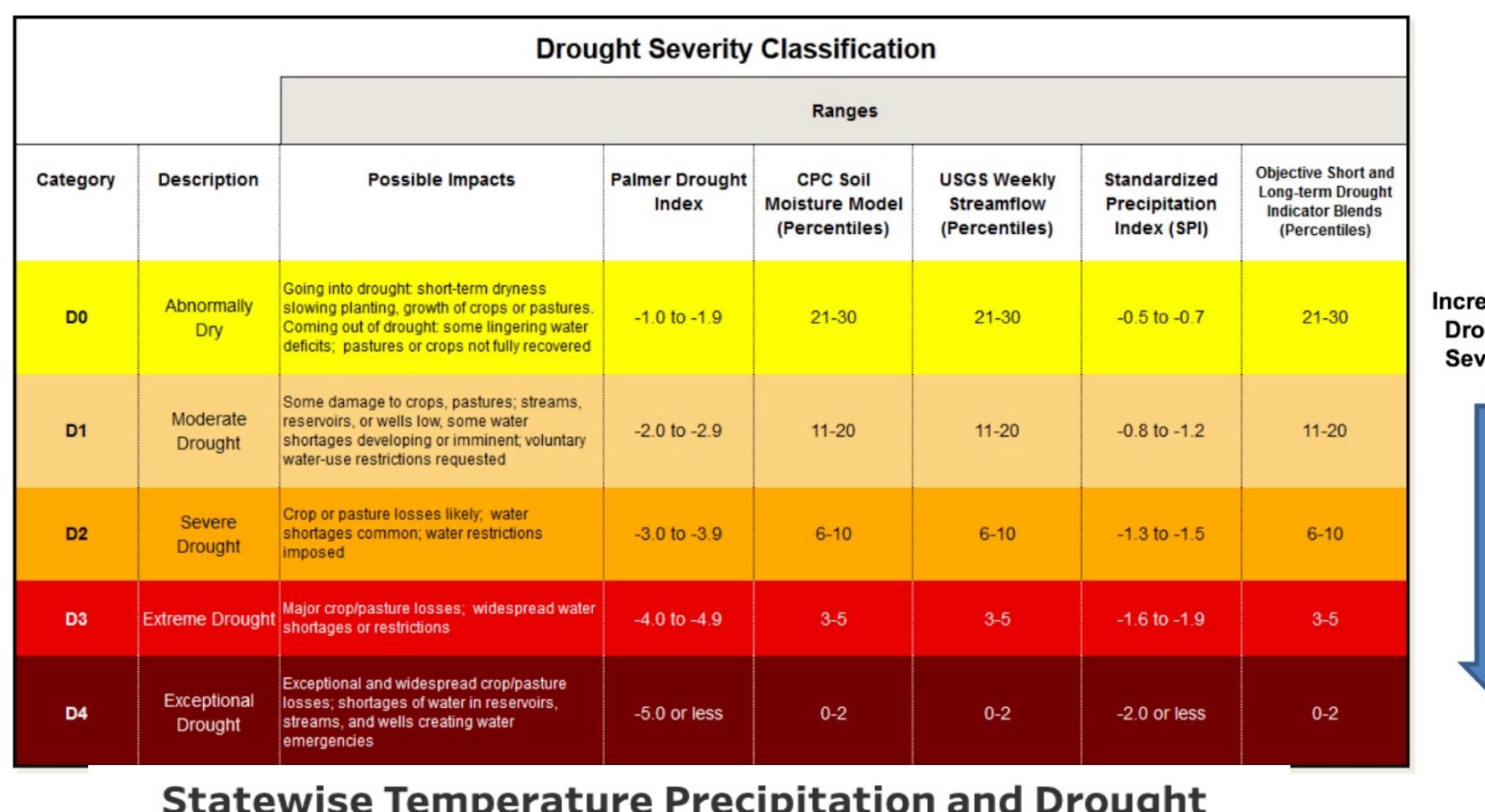
While deliberating on the impacts of drought on the society we chose to focus on the energy sector and specifically on electricity price volatility. Low precipitation and high temperatures present unique challenges to the energy sector which are crucial to analyze and help energy producers and consumers take preventive measures. We analyzed the drought conditions- temperature and precipitation along with drought severity indices such as DSCI and PDSI(Palmer Severity Index) and energy generation-consumption data across the 6 northeastern states under NIDIS: Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, and New York from 2011-to 2020. We collected data from different official government-sponsored sources, including US Energy Information Administration (EIA), US Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and CDC.

Data Collection and Analysis

Dataset Summary:

- Time Scope: 2011-2020
- 54 Features 840 Observations
- Data for the 7 North-Eastern States under NIDIS's northeast DEWS
- Plant level data at the county level for all 7 states aggregated at the state level

#	Column	#	Column	16	MODEL_MIN_WD
0	Year	0	Plant id	17	MODEL_MAX_WD
1	Month	1	Plant name	18	EIA_COOL_TYPE
2	State	2	County	19	EIA_WD_INRANGE
3	Revenue(Thousands \$)	3	State	20	COMP_COOL_TYPE
4	Consumption(Megawatthours)	4	state county fips	21	COMP_DATA_SOURCE
5	Customers(Count)	5	water source	22	COMP_WD
6	Price(Cents/kWh)	6	Latitude	23	COMP_TOTAL_WD
7	Precipitation	7	Longitude	24	COMP_WD_INRANGE
8	Temperature	8	elevation_in_feet	25	NET_GEN_MWH
9	Drought_index	9	com_id	26	NET_WITHDRAWAL
10	D0	10	gen type	27	MIN_CONSUMPTION
11	D1	11	CAPACITY_MW	28	MIN_CONSUMPTION
12	D2	12	CHP	29	MAX_CONSUMPTION
13	D3	13	USGS_WATER_TYPE	30	MIN_CONSUMPTION.1
14	D4	14	MODEL_COOL_TYPE	31	Precipitation_1971-2000
15	PDSI	15	MODEL_WD	32	Precipitation_2011
16	CAPACITY_MW				
17	NET_GEN_MWH				
18	CAPACITY_MWH				



Machine Learning Models

Feature Engineering

- Binning and bucketing
 - E.g., Top 10% in the Drought index
- Feature transformation and feature combination
 - E.g., Precipitation/Temperature
 - Top 25% in temperature and consumption

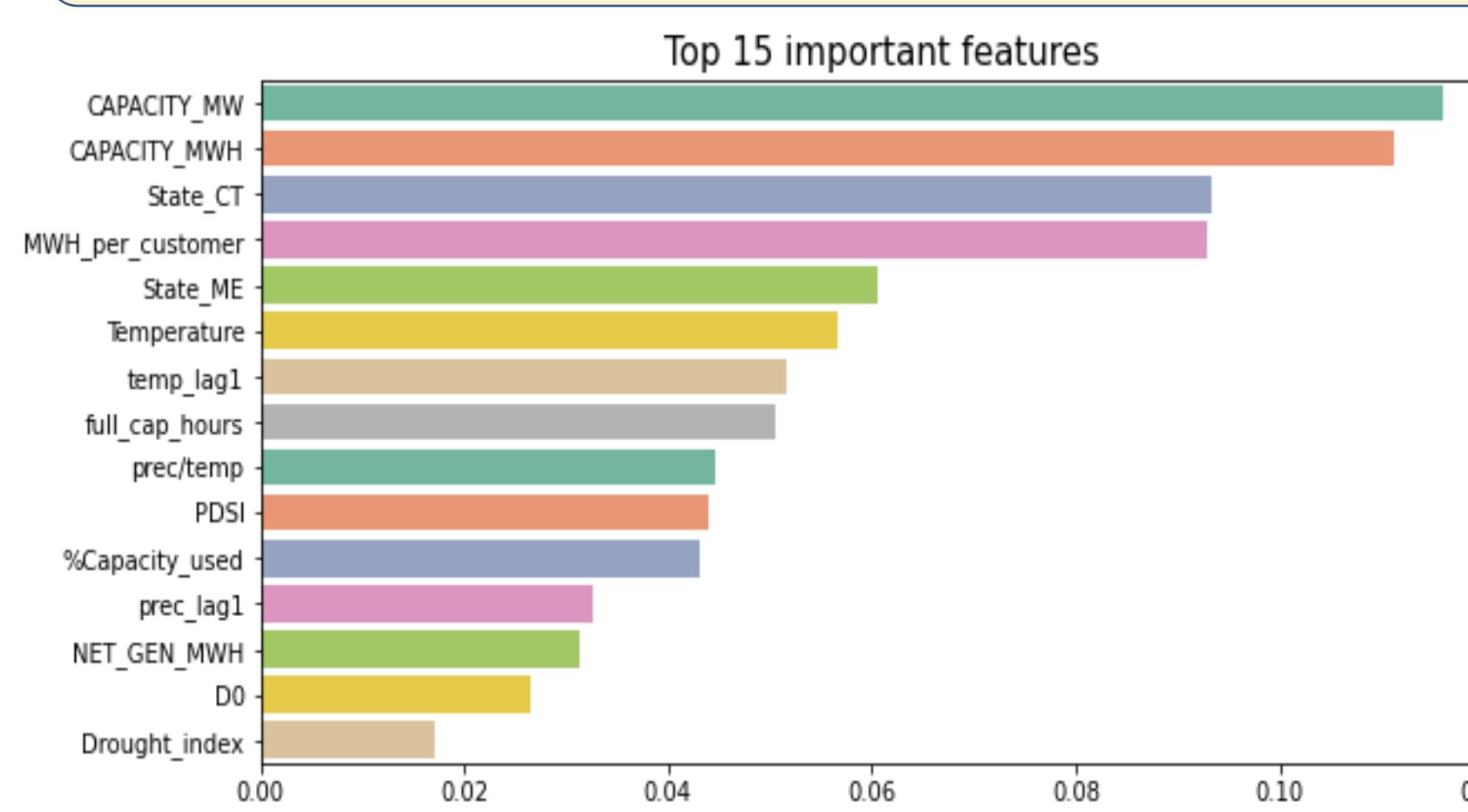
Model selection

- Traditional statistical models
 - Linear Regression
 - Lasso Regression
- Tree-based models
 - Random Forest (BEST MODEL)
 - Gradient Boost Trees

Hyperparameters Tuning

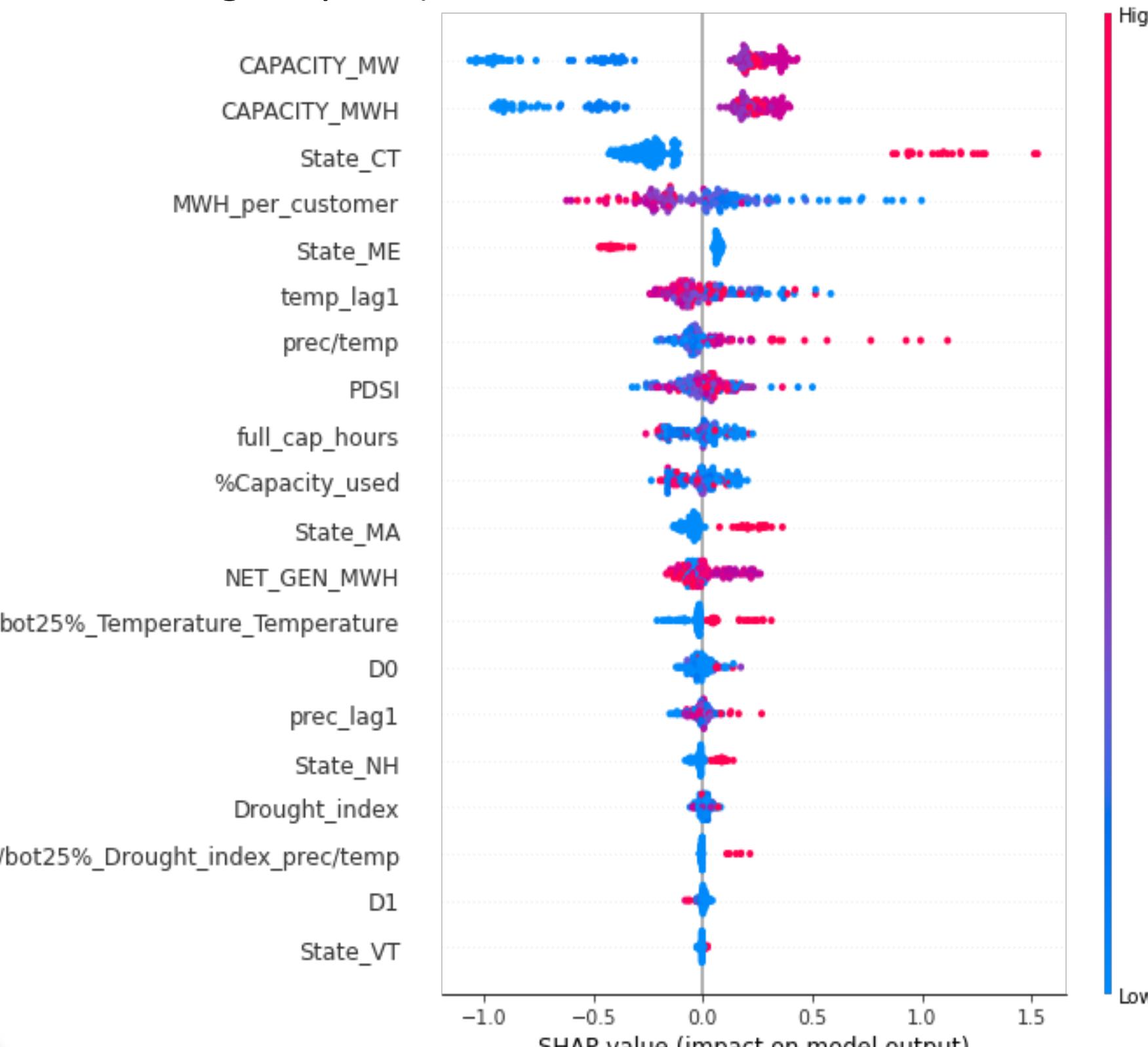
- **Random Forest** (BEST MODEL)
 - Bootstrap, Max depth, Max features,
 - Min samples leaf, Min samples split,
 - N estimators.

Results



High electricity price is positively correlated with

- High temperature in the previous period
- Low electricity consumption per customer
- High PDSI value (Palmer Drought Severity Index)
- High Precipitation/Temperature
- State particular characteristics (ME lower price vs CT higher price)



Limitations and Challenges

- Lack of adequate domain knowledge in drought and energy fields
- Gathering and aligning proper data: Data was very dispersed across both drought(weather-related) and energy websites
- Relying on industry experts and resources to understand which indices to use for drought measurement and determinants of drought conditions
- Prediction of electricity prices depends on many factors apart from the weather which is out of scope for this project

Conclusions

Model Performance (MAE, in cents/kWh)

3.5 ----> 0.85

Improved model performance to predict electricity prices with more accuracy

Project Impact:

Enables individuals and businesses to better understand and plan for electricity consumption
Enables government organizations to take preventive measures to support low-income communities if the electricity prices are forecasted to increase due to drought conditions.

Pitfalls:

Correlation vs. Causation, our model results only shows correlation, while it does not imply causation.

Future Work

- Considering more external and environmental factors like snowfall, cost of fuel, location of the plants, transmission, and distribution systems and government regulations into the model.
- Developing a front-end tool that supports utilities and communities to do electricity price forecasting.
- Applying this project analysis to Western and Central US states which are more impacted by drought conditions

Acknowledgments

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Git-hub and Dashboard Links

- https://github.com/chinarb/BU_NIDIS_TeamA1_Capstone
- https://public.tableau.com/app/profile/chinarb/viz/BU-NIDIS-Capstone-ImpactofDroughtonEnergy/NIDIS-Drought_Electricity_Prices#1