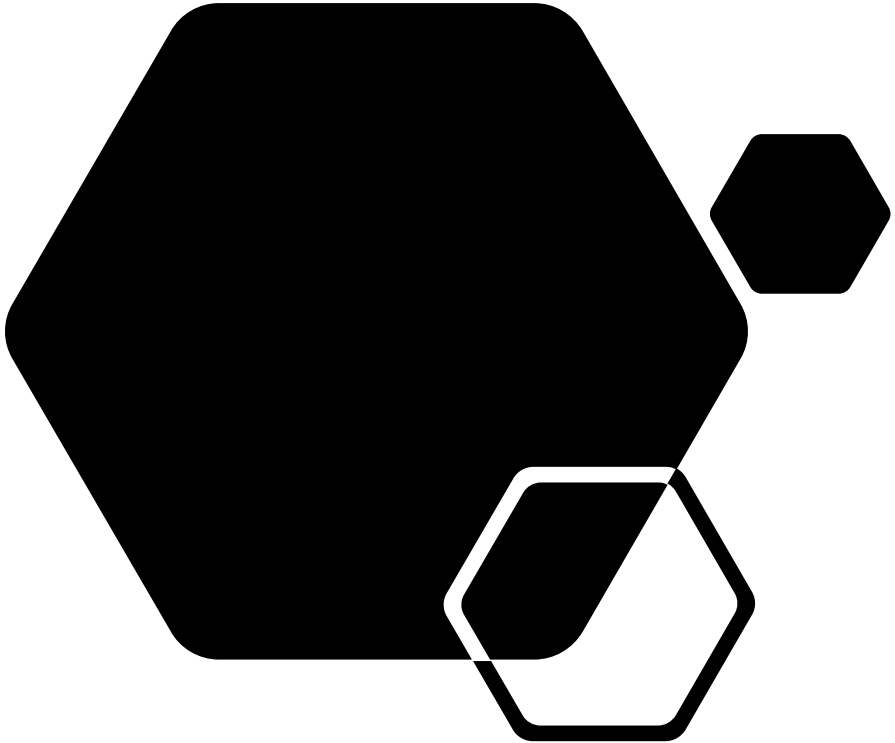
Electric Vehicle Projected Sales

Group 6:
Arnold Tchuente
Hossein Dabiri
Veronica Cheng



OUTLINE

- Introduction
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- Languages and Tools
- Data Exploration
- Visualization
- Machine Learning Models
- Results and Conclusions
- Recommendations for Future Analysis

PROJECT OVERVIEW

Introduction

Electric vehicles (EVs) are the key technology to decarbonise road transport, a sector that accounts for 16% of global emissions.

EVs are gaining popularity and market share. In Q2 2022, EV sales accounted for 5.6% of the total auto market (up from 2.7% in Q2 of 2021). The U.S. Federal Government has set a goal to make half of all new vehicles sold in the U.S. in **2030** zero-emissions vehicles.

However, EV sales in some area have been slow due to higher purchase costs and a lack of charging infrastructure availability.

We want to figure out how the EV market in **New York State** (NYS) in U.S. is projected to grow by the analysis of historical data for EV registrations.

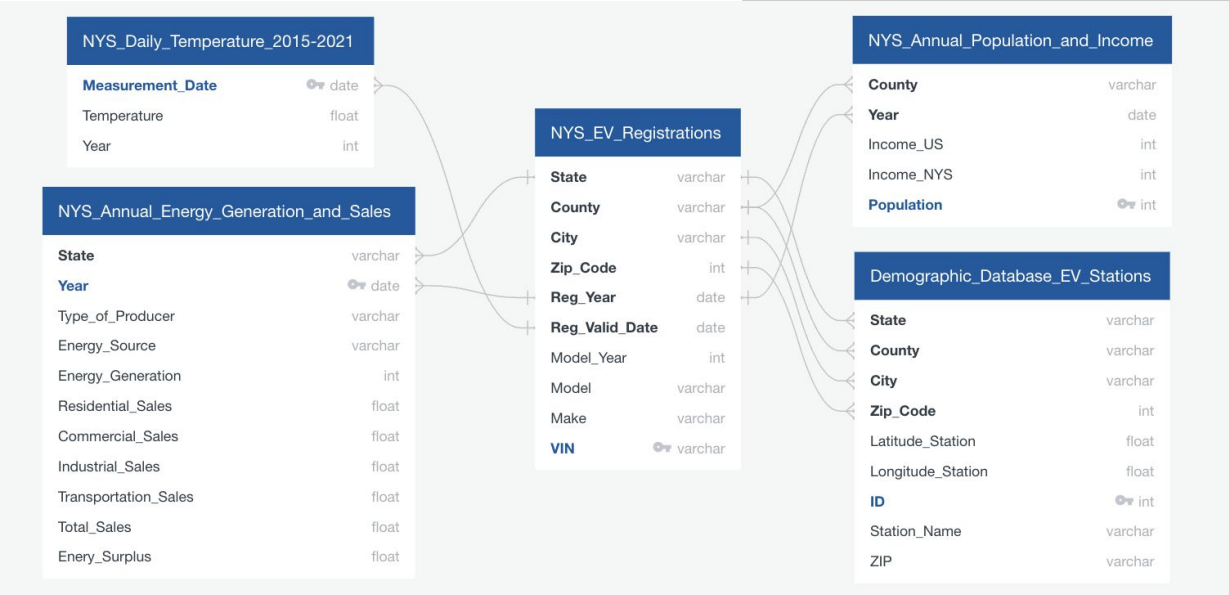
Objectives

After exploring the **EV registrations** and the **number of charging stations** in NYS from 2015 to 2021, machine learning models were built to predict:

- The number of EVs and the demand for EV charging stations in NYS in 2023
- The total EV Adoption by 2050 in NYS
- The Electrical Infrastructure Sustainability for EVs in NYS by 2050

Sources of Data

- The database for this project is connecting to the AWS's relational database service (RDS) using SQLAlchemy and Python.
- The structure of the database and the relations between database objects are designed using the **QuickDBD** tool.



Language and Tools

- In order to get some of our trusted information, we installed 2 additional Python libraries:

  - Meteostat

    The Meteostat Python library provides simple access to open weather and climate data using Pandas. Historical observations and statistics are obtained from Meteostat's bulk data interface and consist of data provided by different public interfaces. Among the data sources are national weather services like the National Oceanic and Atmospheric Administration (NOAA) and Germany's national meteorological service (DWD).

  - Uszipcode

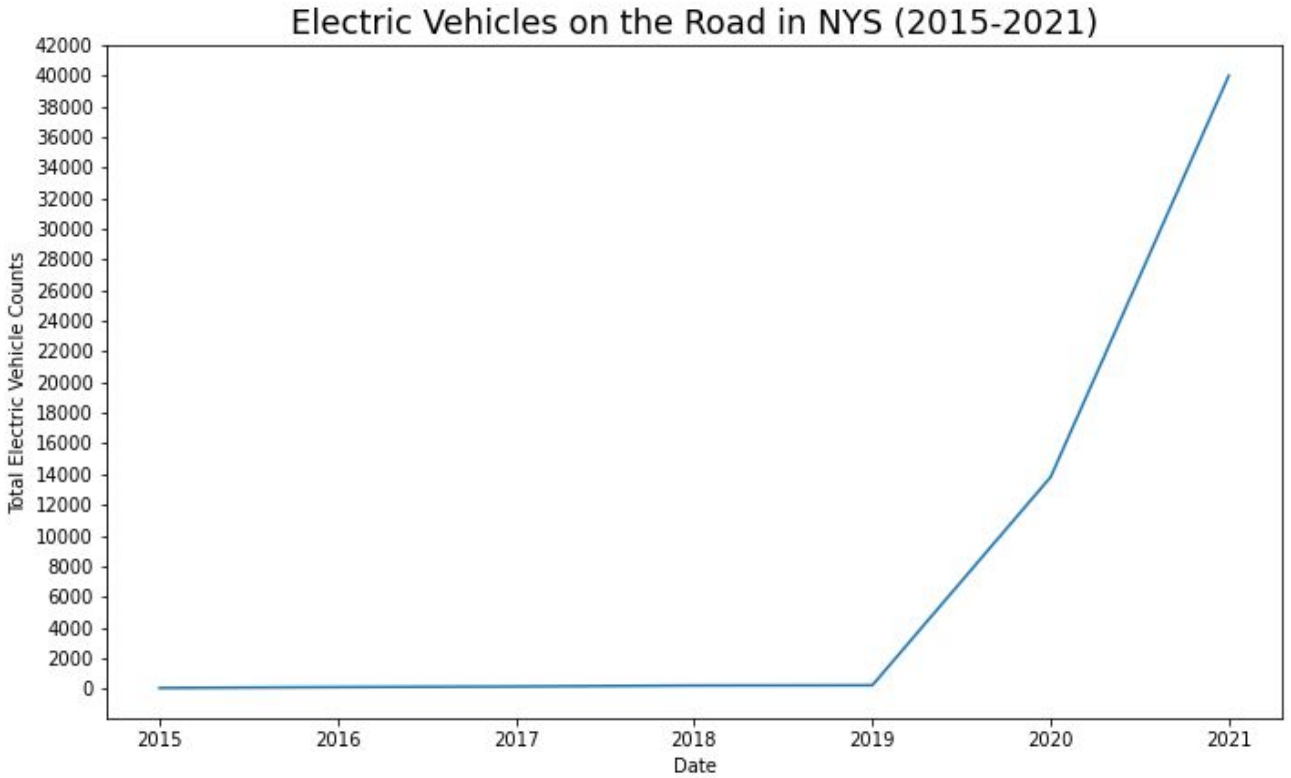
    Uszipcode Python is a famous module released on PyPi used to get the zipcode of a specific location. You can find the zip codes by using City, State, Coordinates, or zip code prefix. The module has already implemented a database containing all the zip codes and their city, state, and map borders.

- Tableau

DATA EXPLORATION

Number of EVs on the Road in NYS (2015-2021)

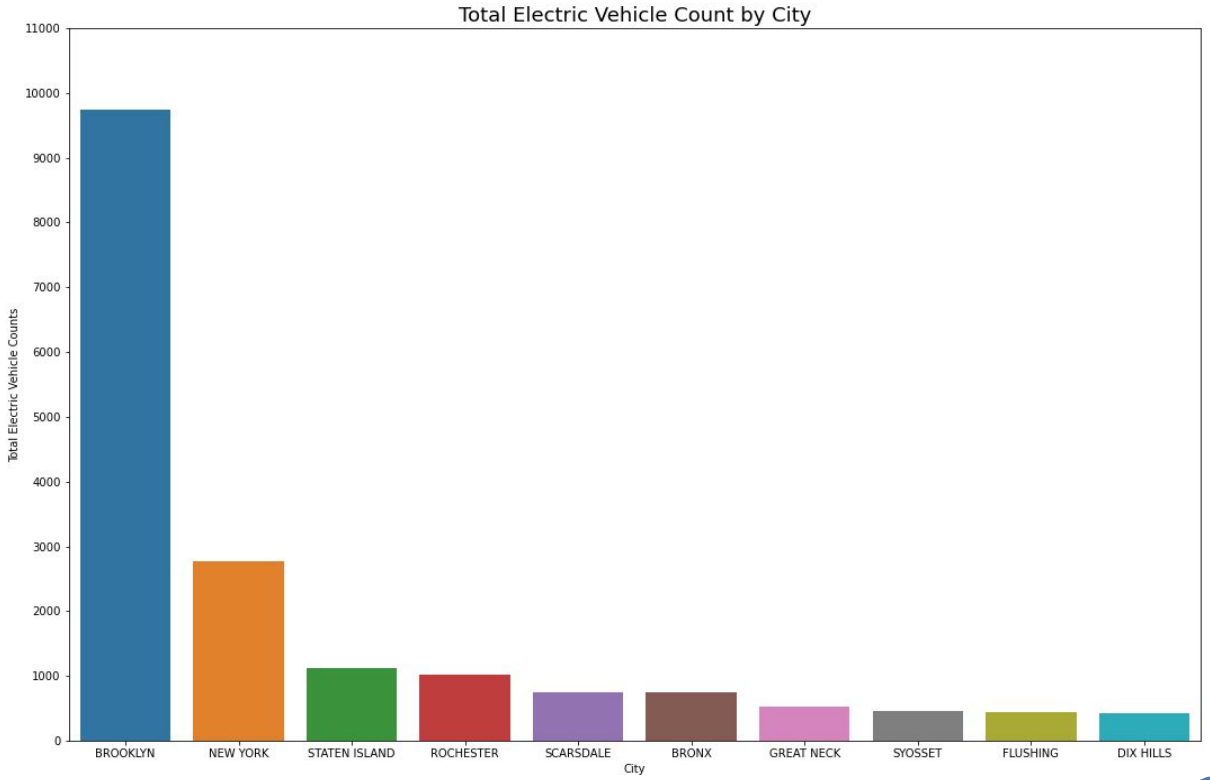
The EV registrations in NYS have been increasing exponentially since 2019.



Total Number of EVs on the Road by City

(from 2015 to 2021)

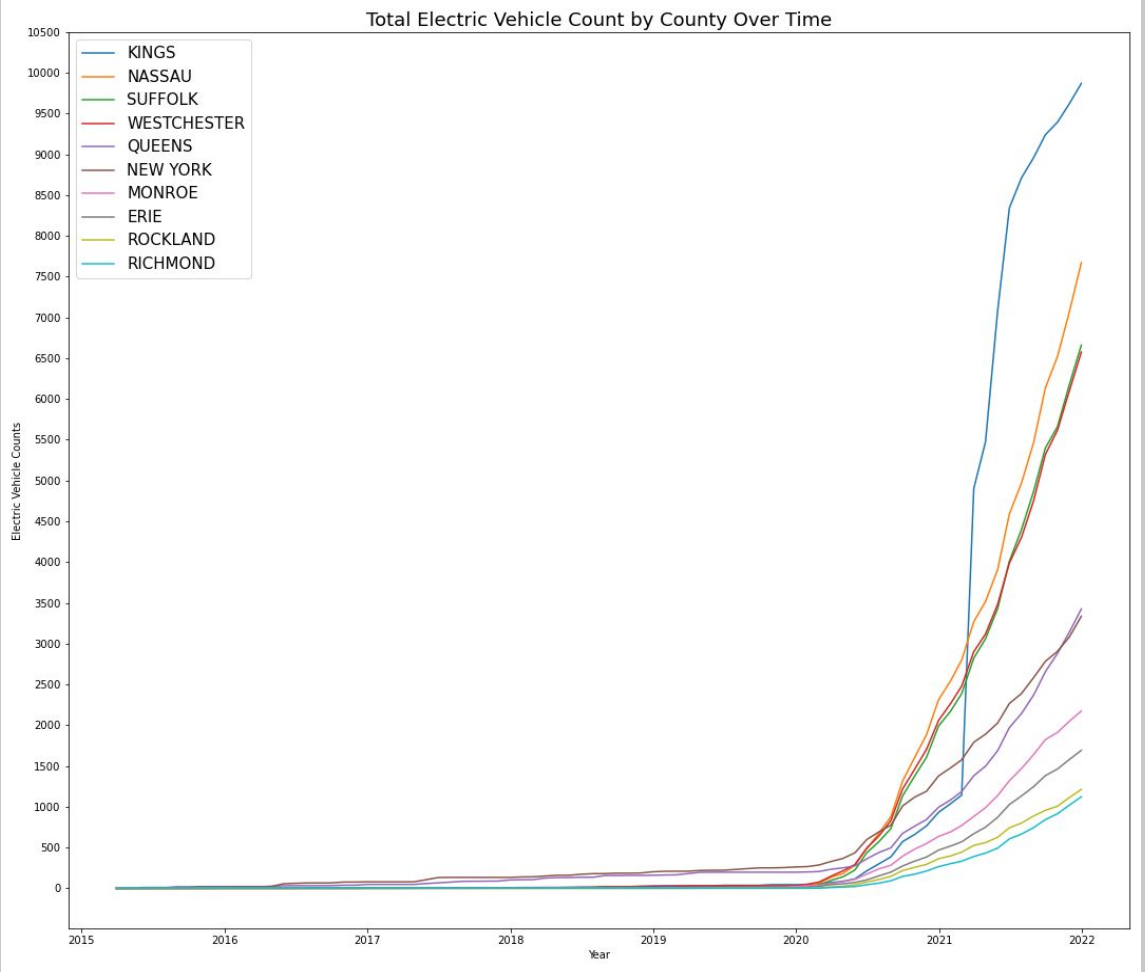
Top 10 cities with the largest total number of EVs in NYS.



Number of EVs on the Road by County (2015-2022)

We explored the EV registrations from 2015 to 2021 in 10 top counties.

Kings County was growing much faster compared to other counties.

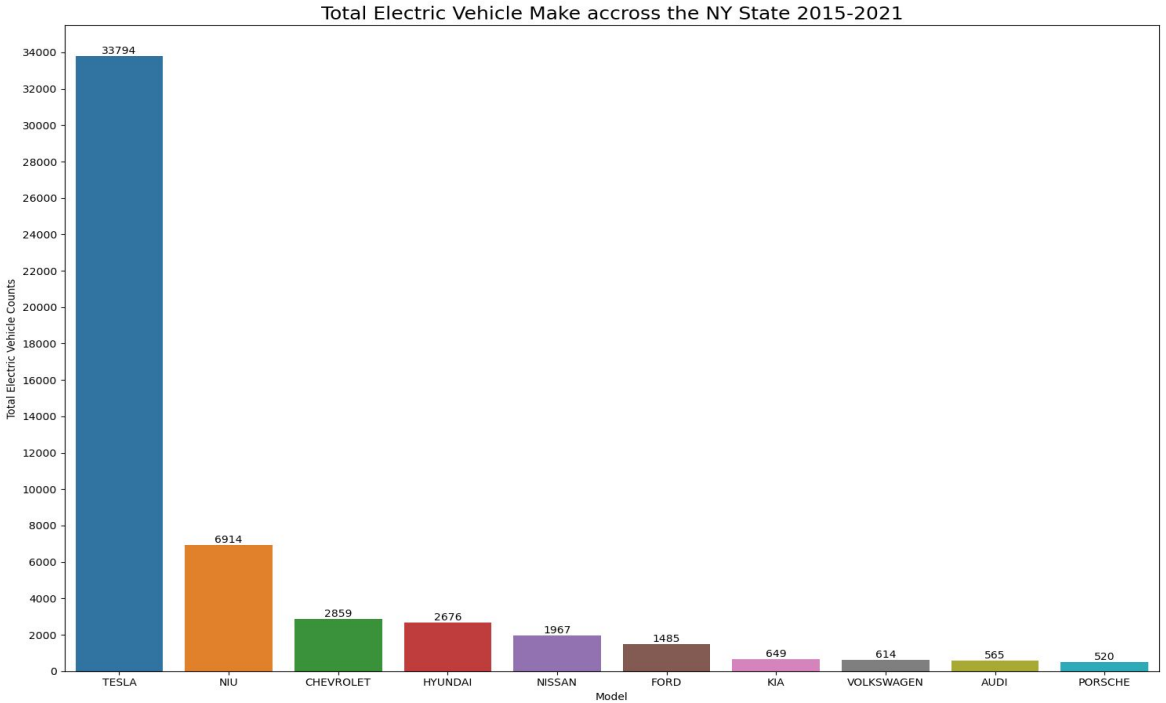


Popularity of EV Models by County

(from 2015 to 2021)

- Overall, **Tesla**, **NIU**,**Chevrolet**, and **Hyundai** were the most purchased EVs in New York State.

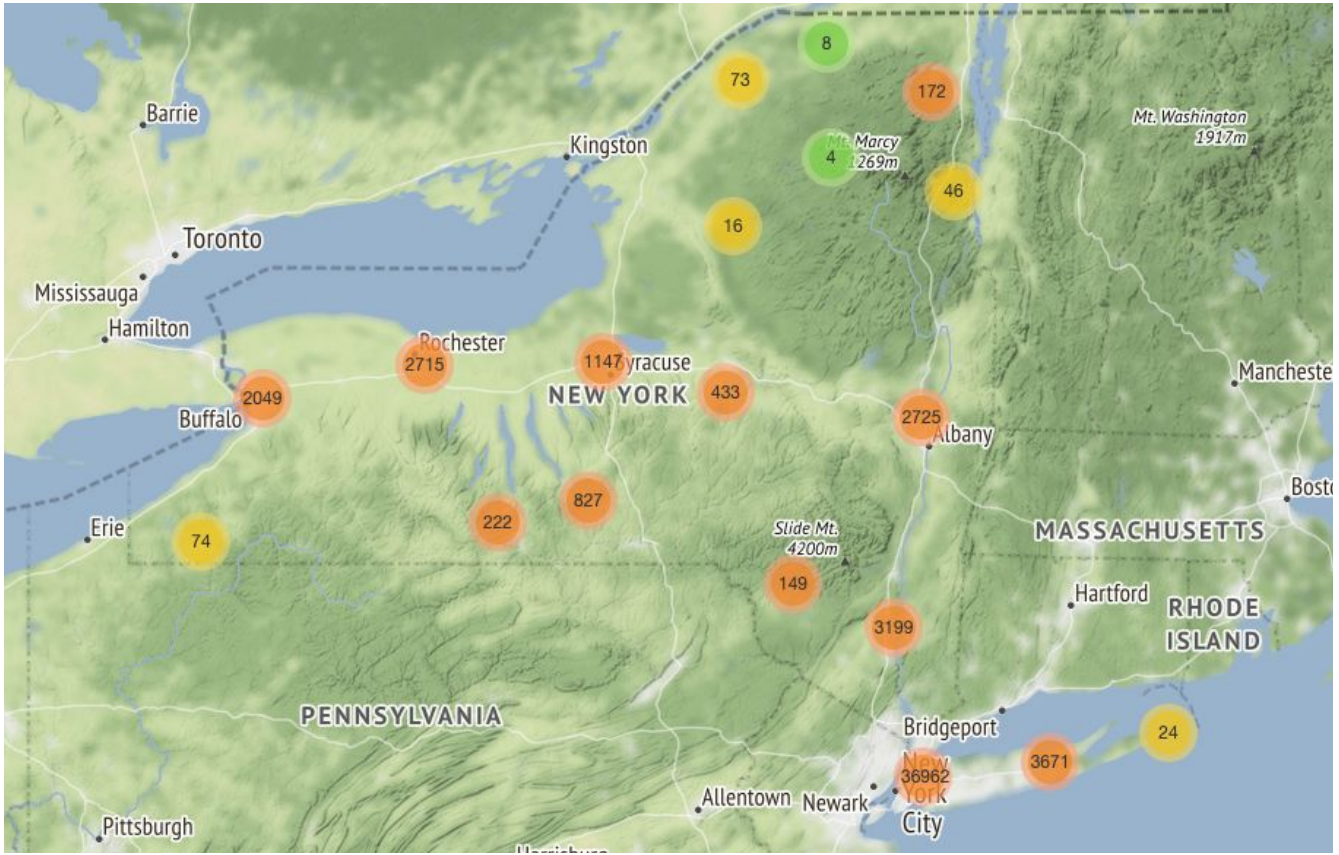
New York State



DATA VISUALIZATION

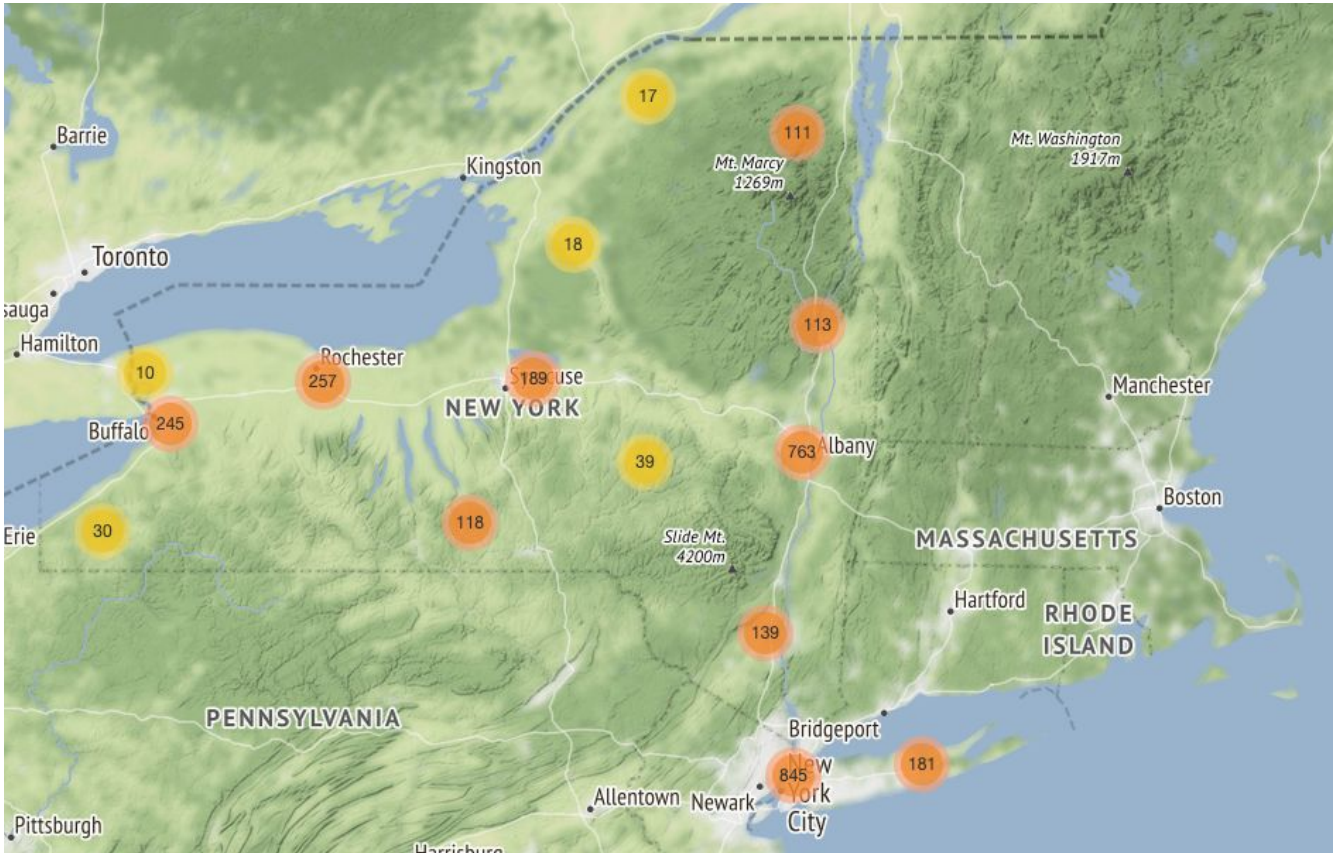
Folium Map

- NYS EV Registrations (54544)



Folium Map

- NYS EV Charging Stations (3082)



MACHINE LEARNING MODELS

PART 1

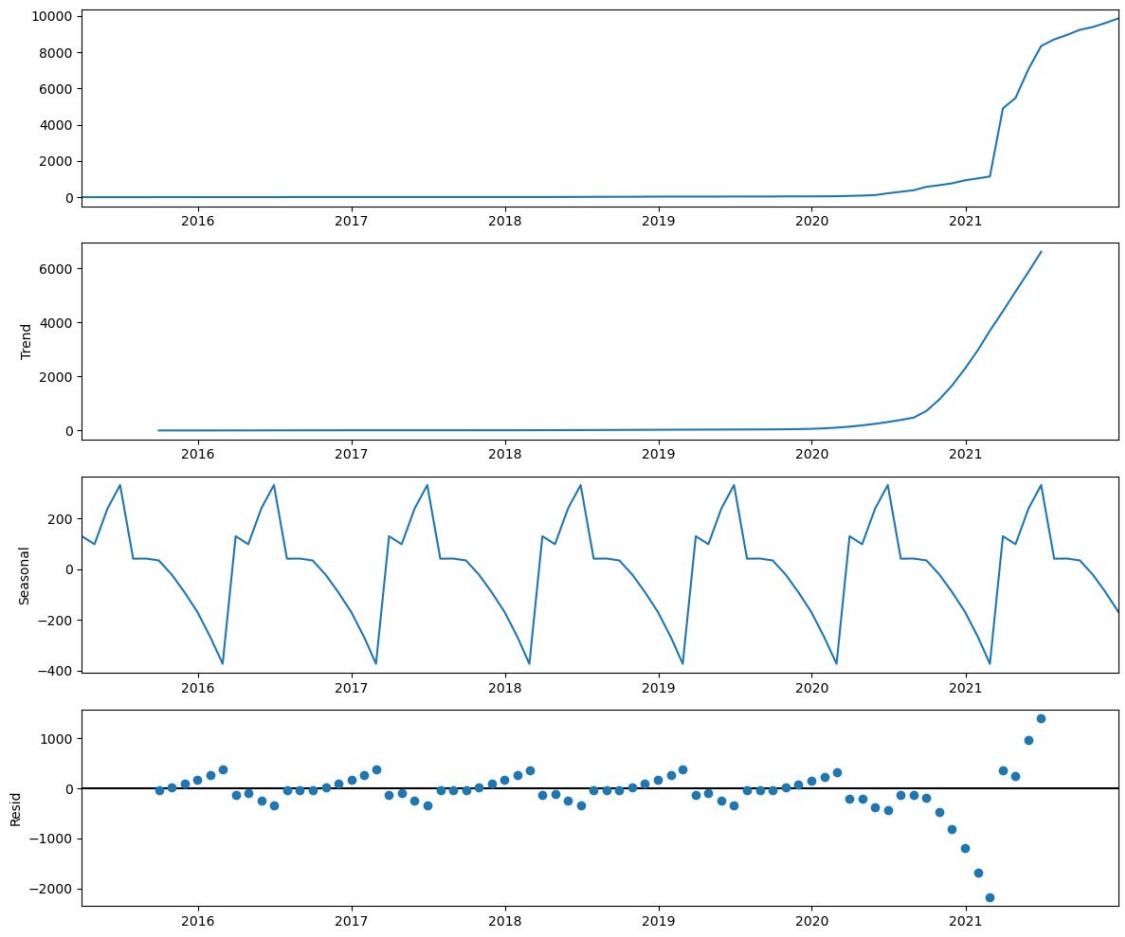
SARIMAX Model

SARIMAX Model

- Predict the number of EVs in the top 6 counties with the most purchased EVs from 2015 to 2021 in NYS.
  - King County, Nassau County, Suffolk County, Westchester County, Queens County, and New York County
- Approach:
  - Perform **Seasonality Check**
  - Split **Train** and **Test** datasets, with a split ratio of 0.85/0.15.
  - Find the best parameters with **Auto-ARIMA.**
  - Predict with SARIMAX model

Seasonality Check

The number of EVs in *Nassau County* had an upward trend and showed a seasonality pattern.

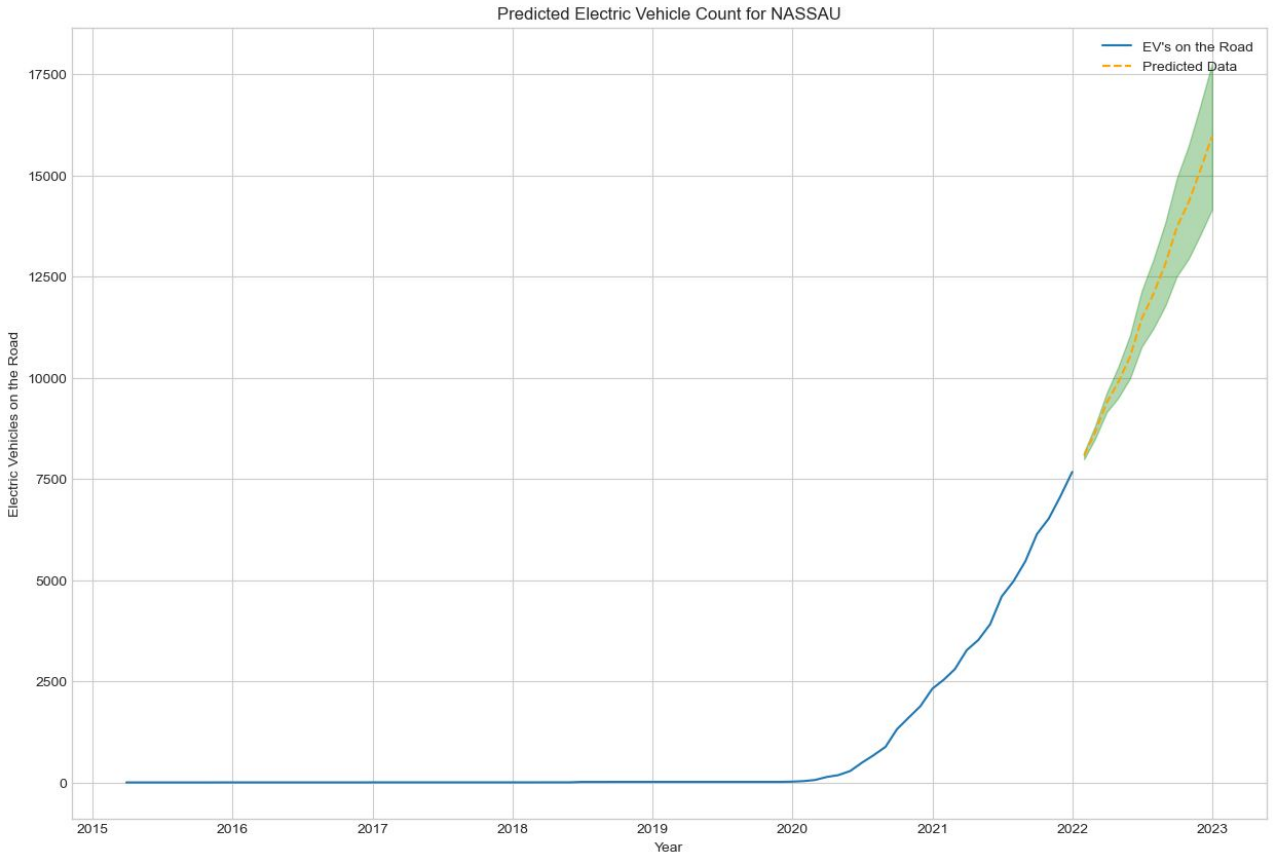


Future Prediction

- Nassau County

The number of EVs are going to keep **increasing**.

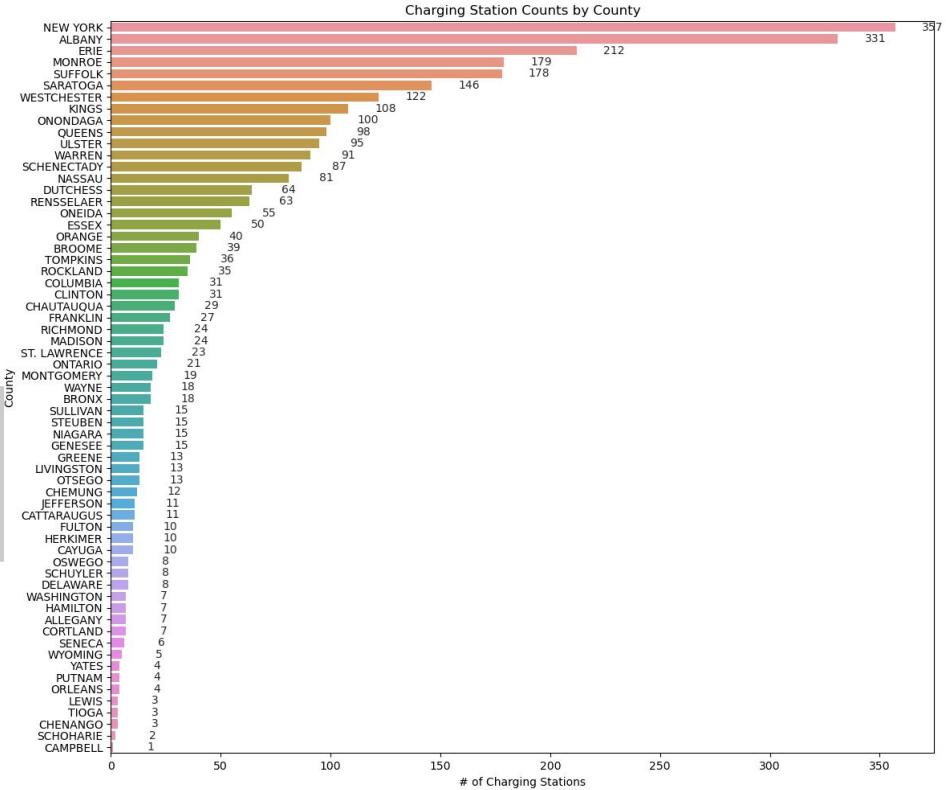
It follows an **exponential pattern** especially in the upper confidence interval.



Current Charging Stations

- We aim to find the top 3 counties to invest for **EV charging stations** based on the predicted number of EVs at the end of 2022 and the current number of Charging Stations.

- New York city has the largest number of EV charging stations.



Demand for EV Charging Stations in 2023

- The table below compares the numbers between existing charging stations and EVs 2021.
- Top 3 counties good to invest for EV charging stations will be **Kings County, Nassau County** and **Westchester County**.

County	EV Count for 2021-05-31	EV Prediction for 2023-08-31	Existing Charger Count	Chargers per EV	EVs per Charger	EVs Added (Today-2023)
NASSAU	7671	15965	81	0.005000	197	8294
WESTCHESTER	6576	12857	122	0.009000	105	6281
KINGS	9870	10722	108	0.010000	99	852
SUFFOLK	6661	13538	178	0.013000	76	6877
QUEENS	3426	6712	98	0.015000	68	3286
NEW YORK	3336	6067	357	0.059000	17	2731

MACHINE LEARNING MODELS

PART 2

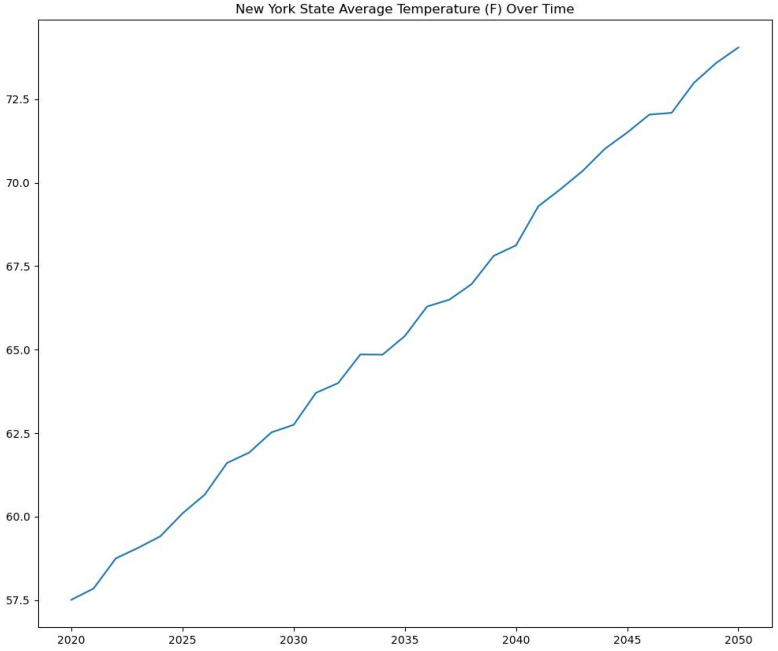
Linear Regression Model

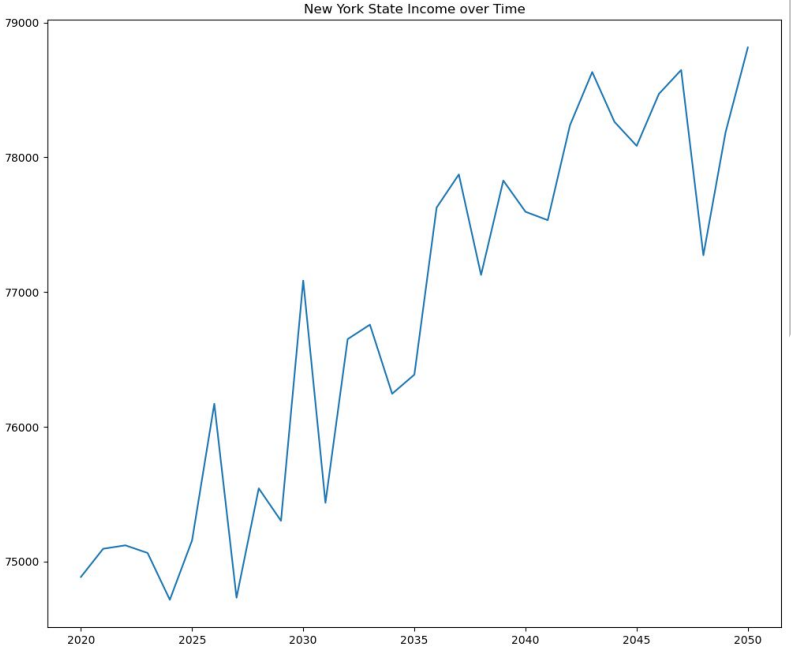
Linear Regression Model

- Predict the total EV adoption in NYS by **2050**, and explore the factors are associated with EV adoption.
  - Features: **ZIP code**, **temperature**, and i**ncome** data of NYS
- Approach:
  - Perform one-hot encoding for the categorical variable, ZIP Code.
  - Hypothesize that the EV adoption follow a **linear pattern.**
  - Fit the data into the linear model, then evaluate the model by the **mean squared error** of the prediction v.s. the true label.
  - Modify the model by removing outlier ZIP codes and generating future **temperature** and **income** data from by 2050.

NYS Temperature and Income Data Generation

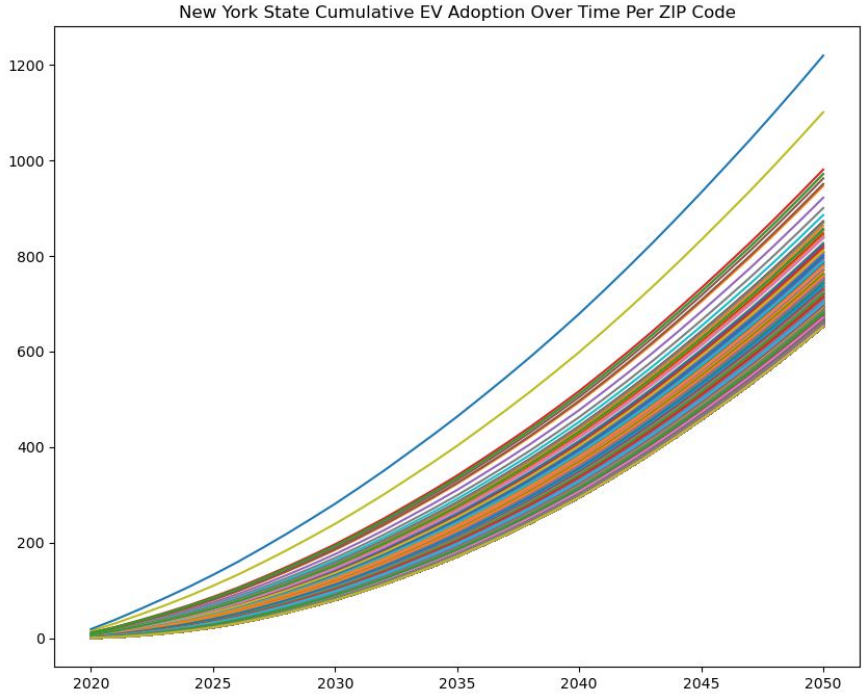
- Hypothesize that NYS temperature and income data follow a **linear pattern**.
- Generate the **future data** by 2050 based on a linear model.
- Add **Gaussian noise** based on the standard deviation of the known data.

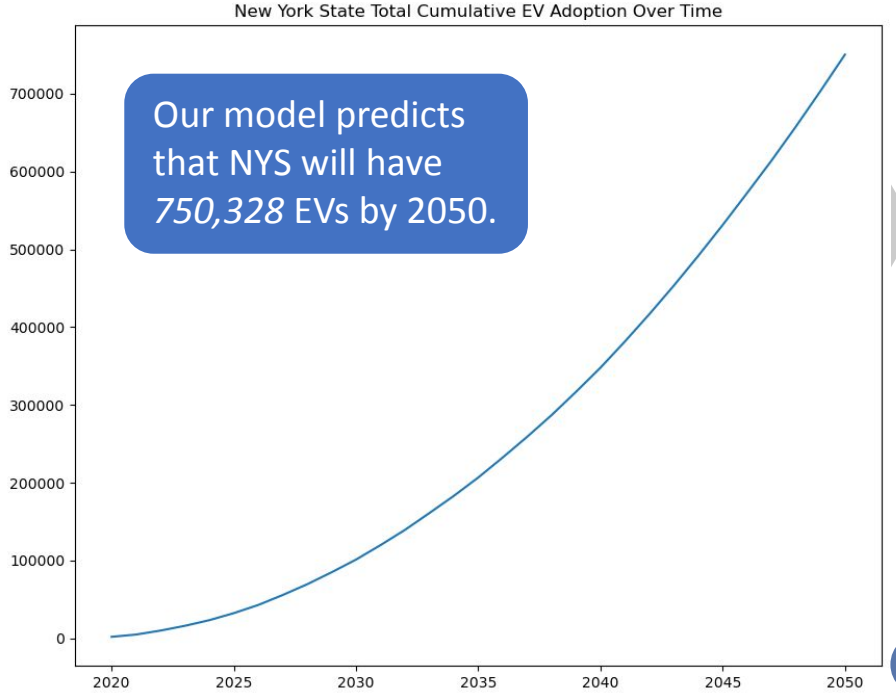




Predict Using the Future Matrix

- Create the future matrix based on the **future temperature** and **income** data, then predict the EV adoption by 2050 using this matrix.





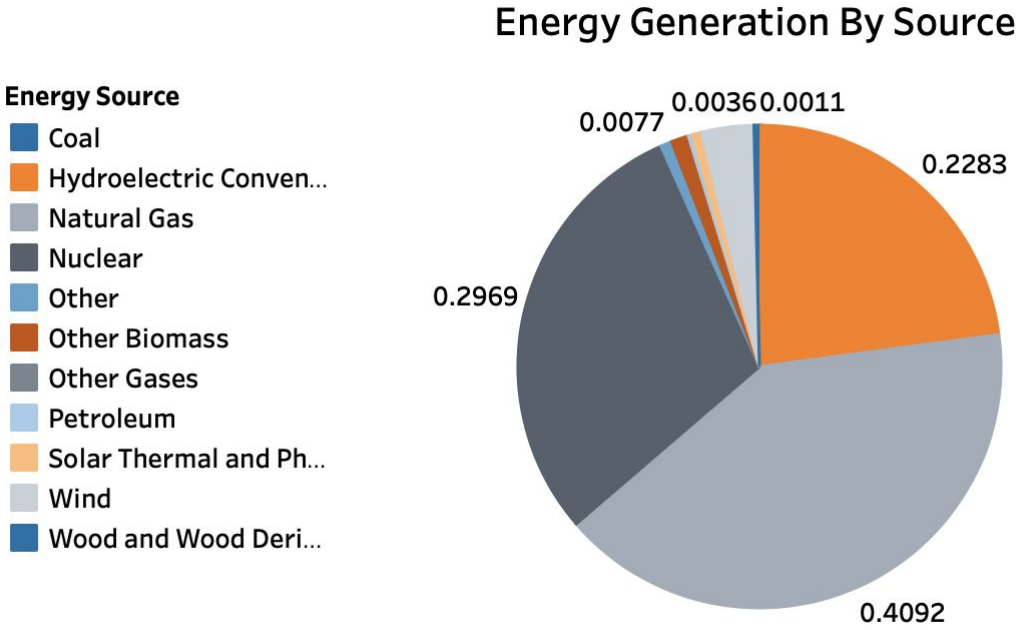
Our model predicts that NYS will have *750,328* EVs by 2050.

Electrical Infrastructure Sustainability for EVs

- Final step was figuring out whether the current electrical infrastructural capacity of NYS can handle the increased number of EVs by **2050**.

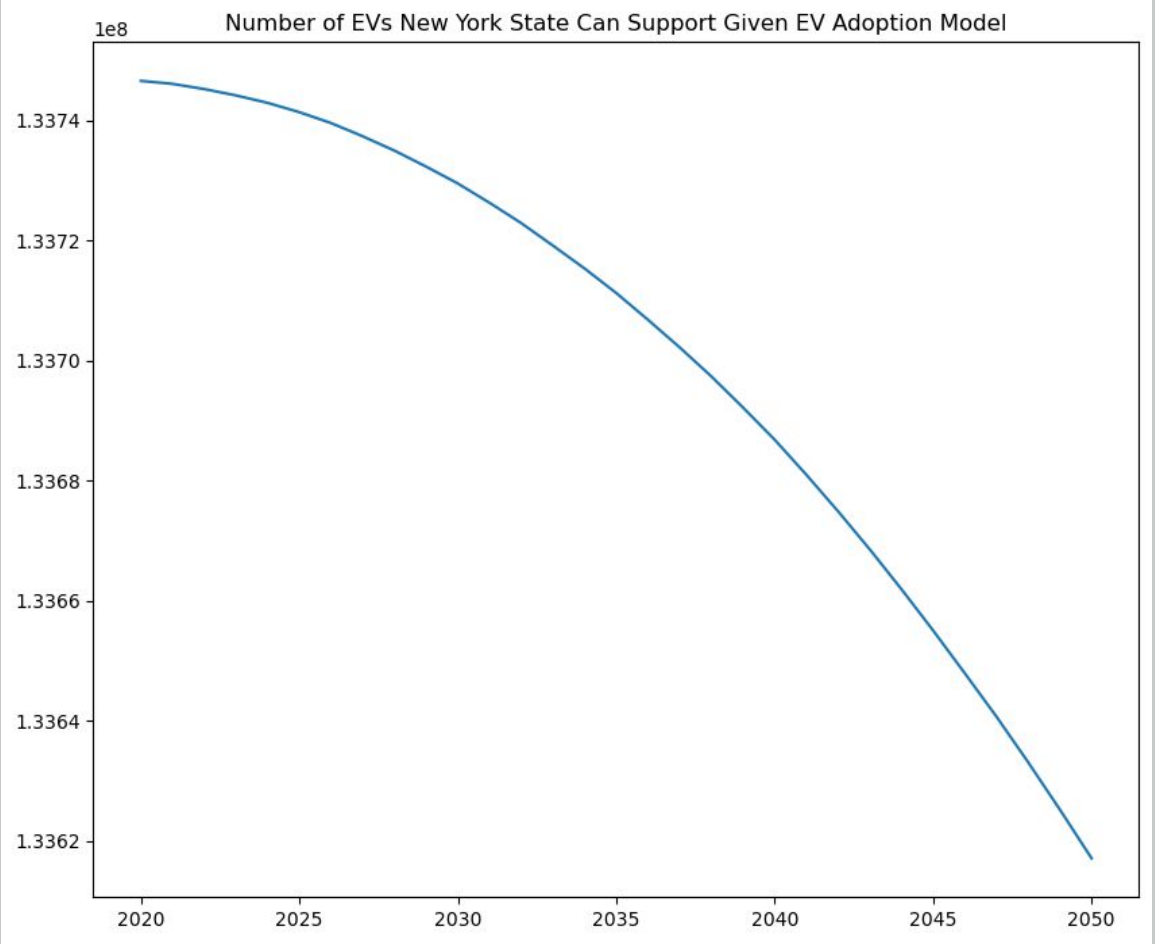
- The **annual average energy surplus** in NYS is 844.1 million MWh.

- About 22% of generated electricity was from renewable energy sources.



Number of EVs NYS Can Support by 2050 Using Energy Generated from Green Sources

This means that even with our projected *750,328* EVs by 2050, NYS will still have enough renewable energy capacity to support all of them.



RESULTS AND RECOMMENDATIONS

Results and Conclusions

- **Brooklyn** city has the largest total number (9738) of EVs in NYS by 2021.
- Top 3 most purchased EV models in NYS are **Tesla**, **Chevrolet**, and **Hyundai**.
- By 2023, **Nassau County** will have the largest predicted number of EVs (15,965).
- Top 3 best counties to invest for charging stations in NYS are **Kings County**, **Nassau County**, and **Westchester County**.
- In total, NYS can support 30.95 million EVs through **renewable energy surplus**.
- NYS will have over 746,238 EVs by 2050. At that time, NYS will still have enough renewable energy capacity to support all of them.

Recommendations for Future Analysis

- Due to time limitations, we had to limit our project to NYS only. There may be other states that are promising for future electric vehicle demand. In the future, we would like to model the EV sales for more states in U.S. to have a more comprehensive analysis.
- Commuting patterns of residents in each county could be considered when analyzing the demand of EV charging stations. Most charging is done at home or at work. Finding counties that people tend to commute into for work, and accounting for this effect by adjusting the anticipated demand for chargers in these counties would result in more accurate recommendations.
- To optimize our model for the EV Adoption in NYS from 2020 to 2050, besides temperature and income, we can also generate the future data for population and energy infrastructure in NYS.

Thank You

Questions?

Appendix

Link to Dashboard

Link to Github