Exploration of EV Chargers in the United States

W200 - Project 2

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Link to Presentation:
https://docs.google.com/presentation/d/15URnJ04USXPs3I_11BGOVDNq_Nq5ZjTx9Wr6J6arbyw/edit#slide=id.g22c9f21728a_1_126

Introduction

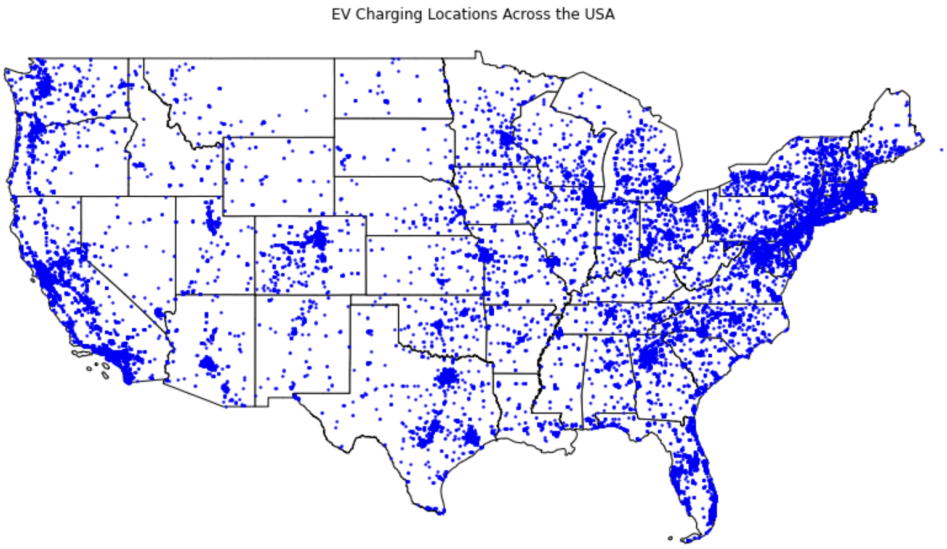


Figure (1)

For the automobile industry, electric vehicles (EVs) mark a pivotal industry shift as more consumers demand cars that are environmentally-friendly. According to the International Electric Agency, over 16.5 million electric vehicles were on the road in 2021. This is a 300% increase from the number of EVs back in 2018. With this emerging market, government policy-making such as the Infrastructure Investment and Jobs Act, is helping reshape the automobile landscape.

In 2021, all-electric vehicles represented 3.1% of US light-vehicle registrations. In 2022 that figure was 5.6%, or 756,534 vehicles [1].

According to the Bureau of Labor Statistics, there are optimistic projections of electric vehicles representing 50% of all light vehicle sales by 2030. However, the discussion of EVs is not complete without discussing EV charging stations. Figure (1) shows all the current EV charging stations across the USA. One of the largest hurdles for the EV market is the infrastructural challenges with EV charging stations and we hope to explore this topic for our research.

Research Questions

The thematic goal for our exploration into EV Charging Stations is to understand the current state of the country's EV infrastructure. We believe our findings can illuminate potential deterrents to purchasing an EV.

Our research questions below covers the EV Charging Station sector in a cascading scope, from a regional/state level view to the major players in this EV sector.

- Are there any regional disparities in where charging stations are placed?
- Which cities are the best at mitigating range anxiety? Are there cities that have high sales of electric vehicles but are underserved with low EV charging station density?
- Are the types of charging stations being deployed changing over time (e.g. level 1 vs level 2 vs DC fast).
- Are companies other than Tesla rolling out charging stations in meaningful quantities?

We hope that by diving into these questions, we can uncover meaningful trends that can inform policy-makers and automakers on what barriers customers face in purchasing electric vehicles.

Summary of Dataset

Our dataset is provided by the US Department of Energy with 70,096 rows of alternative charging stations across the United States. There are 70 columns that cover fields ranging from "location" to "charger type". Fields that were used the most for the analysis include the following:

Field Name	**Description**	**Example**
Fuel Type Code	Identifiers for charger's fuel type	'ELEC' (electric)
City	City of the charging station	**'**Los Angeles'
State	State of the charging station	'California'
Latitude	Latitude of the charging station	'32.367916'
Longitude	Longitude of the charging station	'-86.267021'
EV Level1 EVSE Num	The number of EV Level 1 charger heads located at the charging station	'5'
EV Level2 EVSE Num	The number of EV Level 2 charger heads located at the charging station	'3'
EV DC Fast Count	The number of EV DC charger heads located at the charging station	'2'

Our main assumption for this dataset was assuming that this dataset provided to us represents the most up-to-date copy of all chargers in the United States and there isn't any inaccuracy in the reporting of stations across all states.

Initial Data Exploration and Cleaning

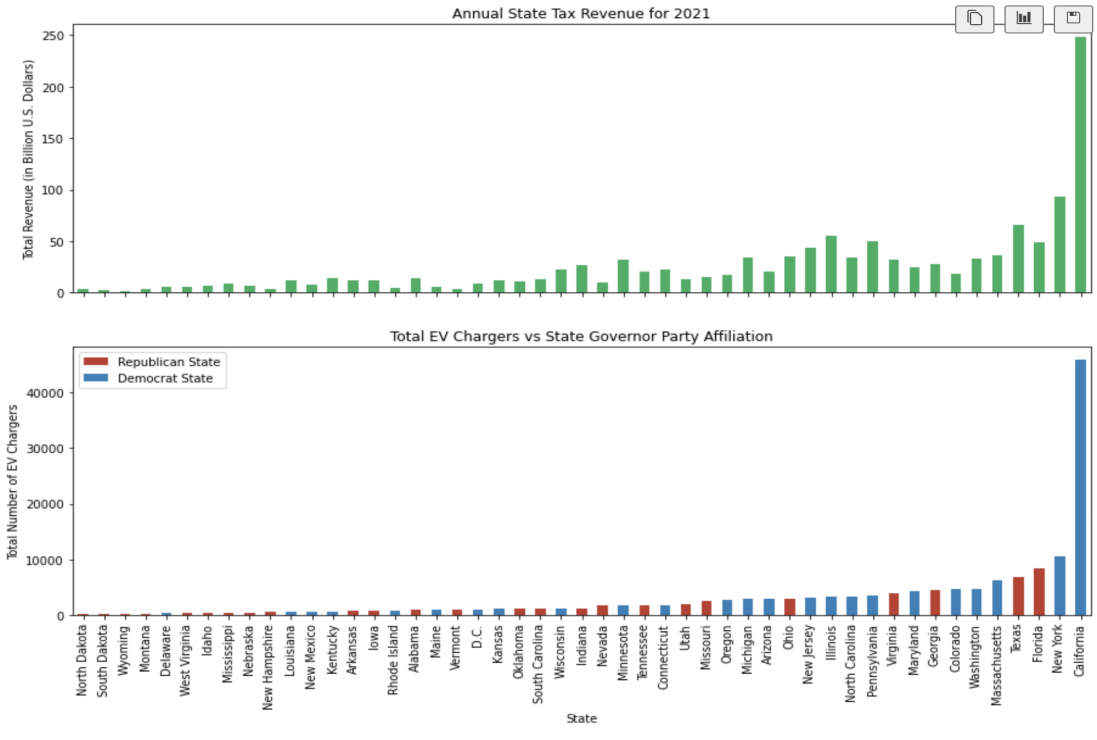
When exploring our dataset, we did not have any duplicates in our data and didn't need to scrub for that. However, our dataset encompasses all types of alternative chargers whereas the scope of our research is to focus on EV Chargers. Part of our group's decision was to filter the "Fuel Type Code" field such that it would include only the key 'ELEC' which refers to EV Chargers. In addition, the "EV Level1 EVSE Num", "EV Level2 EVSE Num", and "EV DC Fast Count" contained some empty values. This seemed reasonable since not all charging stations would contain all three types of charger heads, so we replaced all "Nan" values to "0".

The dataset also contained locations outside of the USA such as Canada and some US territories. We decided to clean the data to only look at the contiguous US which includes the 48 adjoining states and the District of Columbia.

Initial Explorations

After cleaning the data, we started our initial exploration to see the regional disparities of EV charger locations. We sorted the locations of EV chargers by state and started to notice a trend that the states with the most chargers tend to be more Democratic. We decided to compare the total number of chargers versus that state's governor political party affiliation to test our theory. As shown by the 2nd graph below, you can see a correlation with the number of chargers based on a state's political party preference. The top 10 states were 70% Democratic while the bottom 10 states were 80% Republican.

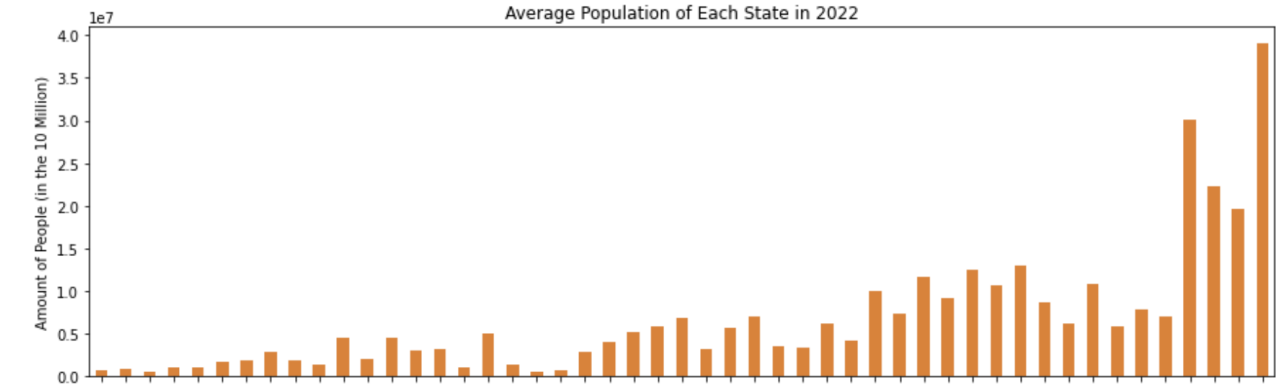
We then decided to check the annual state tax revenue of each state in 2021, and not surprisingly, it correlated with the total number of chargers in each state (as shown in the first

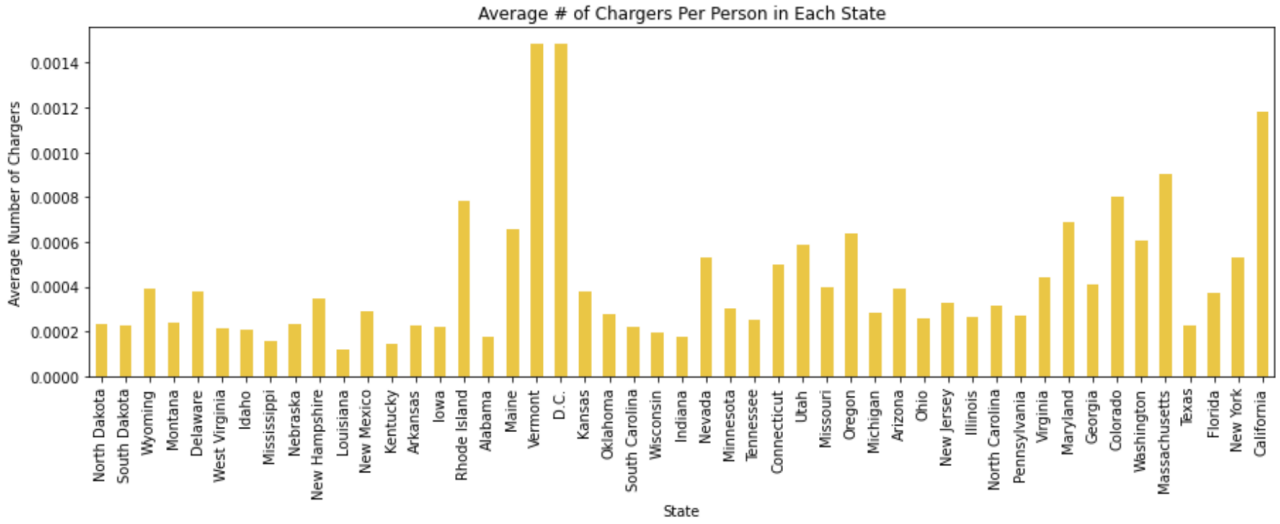


graph below). We found it reasonable that the more money a state receives from its own state tax revenue, the more likely it would invest in installing more EV charging stations. It also made sense that since Republican states value lower state taxes, it would have less revenue to invest into the EV infrastructure. While for Democratic states, they highly value clean energy policies and are more willing to put more money into EV charger expansion.

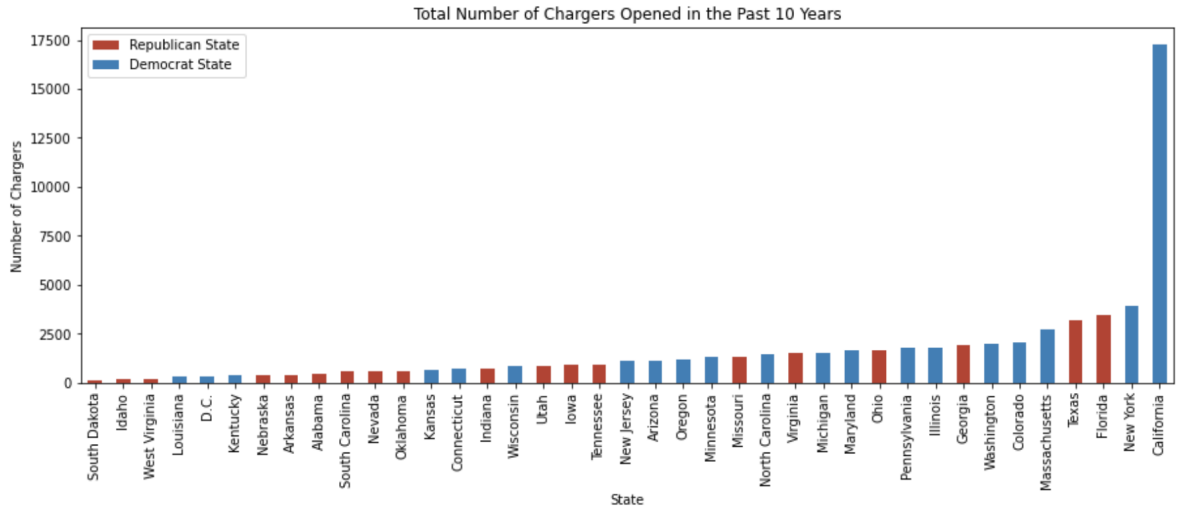
Afterwards we decided to check the average number of available charger heads per person in each state. We pulled the average population of each state in 2022 and kept the order sorted based on the highest number of total charging stations. As shown in the first graph below, it's not surprising to see that the average population of each state correlated with the number of charging stations. The more people there are in each state, the more charging stations that should be available.

However, once we compared the average number of charger heads per person, there was a vast difference in ratios across the states as seen in the 2nd graph below. Despite the top 5 states having the most chargers available, their Charger-to-Person ratio is not that much higher than the rest of the states. We believe this may be due to the challenges of the high population density within the cities of those states. So it raises the challenge of the EV charging station infrastructure trying to keep up with the exponentially growing populations within those top 5 states.





Most of the EV charging stations we see today were installed within the past 10 years. As shown in the graph below, the majority of the new EV charging stations have been installed in California. We believe the reason for all the EV chargers in California is due to the electric vehicle company–Tesla. Tesla was originally headquartered in California when they first started coming out with their electric vehicles. Due to the rising popularity of their EV models, it created a revolutionary movement to expand the EV infrastructure across the country.



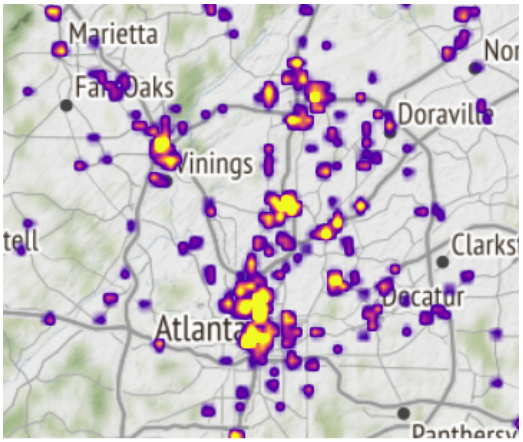
	count	land_sq_mi	EV Charger Density
Los Angeles	1644	469.50	3.501597
San Diego	808	325.90	2.479288
Irvine	628	65.60	9.573171
Atlanta	621	133.20	4.662162
Austin	602	319.90	1.881838
San Jose	585	178.20	3.282828
Kansas City	489	314.70	1.553861
San Francisco	487	46.90	10.383795
Seattle	452	84.00	5.380952
Boston	444	48.34	9.184940
Menlo Park	404	9.99	40.440440
New York	377	300.40	1.254993
Washington	363	61.10	5.941080
Sacramento	359	97.70	3.674514
Chicago	349	227.70	1.532718

In this table to the left, we highlighted the top 15 cities by number of EV charging stations and calculated their respective density by charging station. Our findings show that certain cities with higher densities are well situated for the growth in electric cars but we need to check for any regional disparity not noted by this

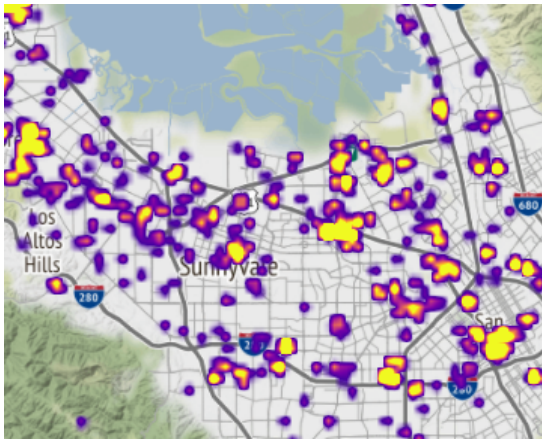
In this table, we calculated the average number of miles to the nearest charging station. This essentially informs us how far, on average, would we have to go to the next charging if we were to be randomly dropped at any charging station. This is fascinating because despite cities like Atlanta having a large number of charging stations and a strong density amount, their miles are skewed which indicates the need to dive deeper.

City	miles_to_nearest_charger
Atlanta	10.416881
Austin	2.707273
Boston	0.033747
Chicago	0.149132
Irvine	0.022565
Kansas City	0.035863
Los Angeles	0.121391
Menlo Park	0.015406
New York	0.564606
Sacramento	0.110485
San Diego	0.089373
San Francisco	0.054628
San Jose	0.069125
Seattle	0.118719
Washington	5.683535

Atlanta, GA



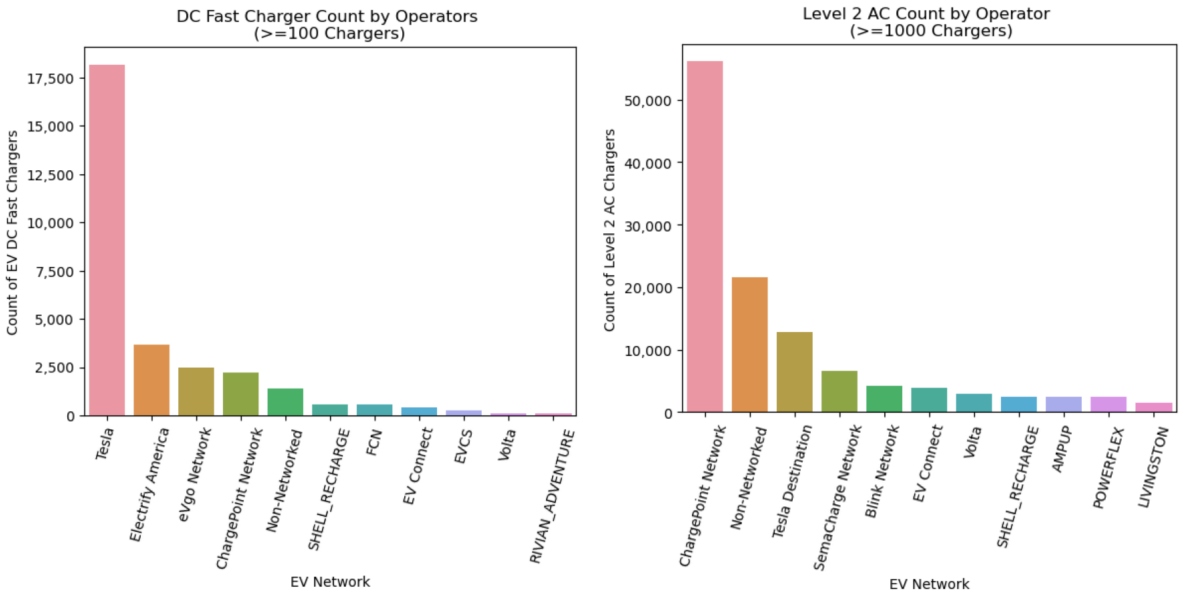
San Jose/South Bay Area, CA



We developed an interactive heat map that showcases where EV charging stations are currently located across the US. In relation to our findings earlier, we can see that cities like Atlanta have a strong presence of EV chargers but they are densely located across certain regions, such as major highways in this example. On the other hand, cities like San Jose have a more equally distributed placement of chargers which indicates that these cities are more friendly to electric vehicles. These findings are important because it demonstrates how there are disparities in the city level where there are communities that are underserved and need better access to alternative charging station options.

Charging Providers

Given the growth in supply of electric vehicles from small startups such as Tesla in the 2010's to almost all passenger car manufacturers (Ford, GM, the VW group, etc.) we were curious to see who the charging networks were being established and operated by.

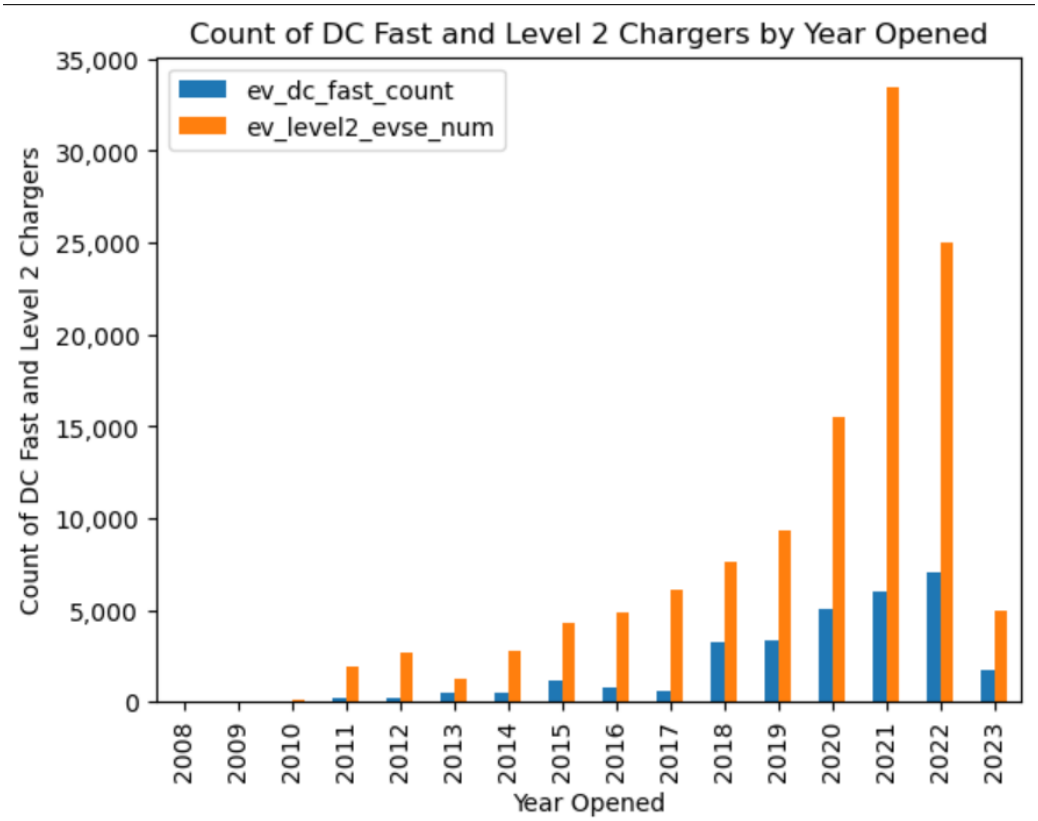


Upon grouping the number of level 2 and DC fast chargers by network operator, we found there remains a virtual monopoly on DC fast charging held by Tesla. This is particularly problematic in light of most of Tesla's chargers being closed to other automakers' vehicles.

Interestingly in level 2 (a.k.a. 'destination') charging, Chargepoint holds the vast majority of market share. This is particularly interesting given they are a publicly traded network operator, and do not sell vehicles.

Key takeaways from this analysis is that additional investments in non-proprietary DC fast charging infrastructure are desperately needed to keep pace with the volume of non-tesla EVs being sold in the United States.

Charger Deployments Over Time



A key indicator in how charger deployments of both varieties are growing over time is new chargers opened by year.

One interesting discovery is that public level 1 chargers have been discontinued, as electric vehicle batteries have grown in capacity beyond and require more energy to fuel.

The graph above shows charger deployments filtered on the year 2008 and onward. Previous to 2008, there were an immaterial number of chargers deployed nationally, so we chose to focus in on more recent history.

Interestingly, the clustered bar graph above shows that public level 2 (orange) charger deployments actually decreased from 2021 to 2022, which is unexpected given the continued record-breaking growth in electric vehicle sales each year.

DC fast chargers (in blue) continue to increase annually. Given the latest federal infrastructure subsidies, 2023 should continue to see record high charger deployments to match the pace of new EV sales.

Conclusion

The electric vehicle charging experience has disparities across states, cities, and neighborhoods. The explosion in sales of EVs is outpacing the deployment of charging infrastructure. This presents short-term challenges, but also a long-term opportunity for charge point operators, automakers, and policymakers to establish themselves in a nascent industry.

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