



GEAR

Gaps Explorer for Accessibility and Readiness:
California Electric Vehicle Charging Infrastructure

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Hi everyone, we are the GEAR team, consisting of Yin, Wenqi, Coco and Alison.

We are excited to present our Gaps Explorer for California's Electric Vehicle Charging Infrastructure, with the guidance of our very own Professor Marti Hearst.

Goal

Our project goal is to monitor our readiness in California's EV transition by understanding the gaps in the accessibility of EV charging infrastructure.



First, let's provide some project background. Electric vehicles are cool looking and having lots of environmental benefits. California government has set the goal that 100% New Cars Sales should be Zero-Emission by 2035. However, today only 2.2 % of the cars on the road are electric and the charging infrastructure still has huge gaps.

So, our project goal is to monitor our readiness in California's EV transition by understanding the gaps in the accessibility of EV charging infrastructure.

Data and Tools

DATA

- 2019 California Vehicle Survey (NREL)
- Charging Infrastructure Data (NREL)
- 2010 Census Data and 2017 American Community Survey (USCB)
- Urban/Rural Code
- CalEnviroScreen 3.0 Score and SB 535 Disadvantaged Communities (OEHHA)
- Forecasted number of chargers in San Francisco and Los Angeles (ICCT)

TOOLS

- React.js, Create-react-app
- Python (Pandas, GeoPandas, Numpy, Seaborn, Plotly, NLTK, PyTorch, Scikit-learn)
- D3 chart libraries (Rechart, Nivo)
- Tableau
- Adobe Illustrator

Here are the data and tools we used.

We used Python for data collection, preprocessing and NLP models.

We also conducted exploratory data analysis for different datasets. Most data are open source from government websites, except for the forecasted data kindly shared by the think tank of International Council on Clean Transportation.

We built our information visualizations using D3 chart libraries, Tableau and Adobe Illustrator. And We used Create-react-app to implement the website.

Website Storyline

- **Landing Information**
 - **EV Charger Types**
 - **EV Drivers Persona**
 - **EV Charging Issues**
 - **Gaps in Equity**
 - **Gaps in Scale**
 - **A Future to Look Forward to**
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Our final results starts from an Introduction of the current situation, including charger types, driver persona and the problem they currently face. Then we focus on discussing the EV charger gaps in two main aspects, Equity and Scale. And we concluded with some takeaways and a vision of the future.

Project Result DEMO

Now we will present our project results through a demo on our website.

<https://alison626k.github.io/MIMS21-GEAR/>

Charger Types & Driver Persona



High Income
(>90k/year)
14.9%



Mid Income
(90k-36k/year)
77.6%



Low Income
(<36k/year)
7.5%



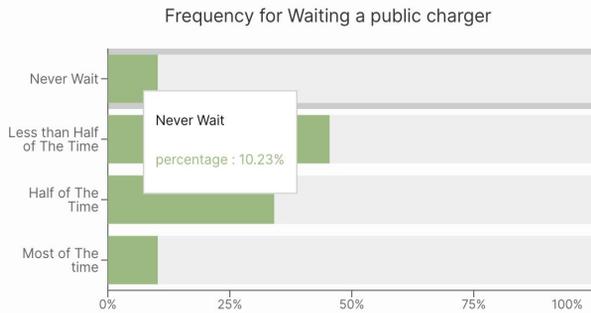
Level 1 (120V)

- Mostly overnight home charging, any normal socket, J1772 charge port
- 👉 Most common in residential garage.
- 👉 No additional infrastructure.
- 👉 Charge slowly, 8 hours can supply 40 miles of range, 16-40 hours for full range.
- 🍎 Like "EVs on diet", slow intake, sometimes low energy in the day and need a boost to make it home.

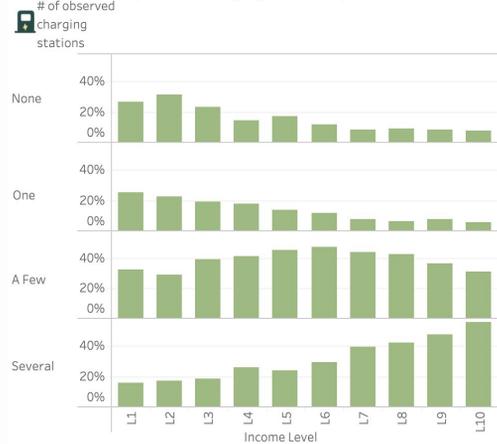
At the beginning, we introduce some background of California's EV situation. Then we explain the features of three types of EV chargers so people can understand them for the rest of the discussion. We use gauge charts to visualize their charging miles per hour, and list their use cases, pros and cons and a metaphor.

For EV driver persona, we use icons to describe our current EV drivers features. The data shows that most EV drivers are in the mid to higher income levels, and they mostly live in a single family houses. Tesla is their top brand choice, but they also have many other brand options. They mostly use Level 2 chargers.

EV Charging Issues



Observed Nearby Public Charging Station by Income Level



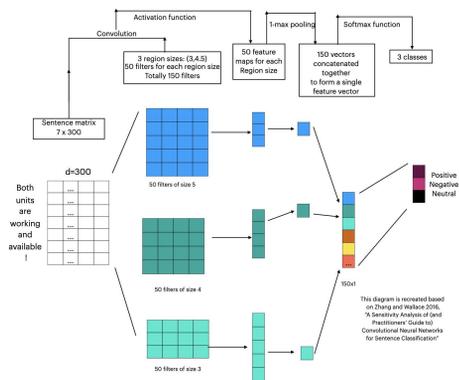
There are 3 main issues the EV drivers currently face:

First, they often wait for a public charger. In the survey, 44% of drivers mention that they have to wait for a charger over half of their times. These bothers them quite a bit.

Second, higher income people have access to more chargers. So for the middle or lower income group, it's not convenient to come by a charger nearby.

Third, 80% EV drivers say that they would sometimes avoid driving their EVs due to the lack of available chargers.

Sentiment Analysis on reviews on EV Charging Stations



..9/30/13. charge point 2 units **not working and/or not connected to network**. No exclusive signs for EV so spots taken by ICEs.



.. However, **after more than an hour**, it said 3.6xx kWh, and only read **12% battery** in my C-Max Energy, which should have been over 50%. Something not quite right here. Good luck!



Dc quick charger would shut off after just a few seconds. No phone number to call on the unit. I got **zero charge** and **was stranded** due to this unit not working. I had some faith and traveled far and was let down. Today.

Charging infrastructure plays a significant role. In order to understand more about the challenges EV drivers face when charging, we used NLP technique to conduct sentiment analysis for reviews at charging stations. On the right side are some of the typical EV charging station reviews, expressing different concerns and problems. For example, a driver's car was stranded and could not charge. We predict sentiment for each topic contained in each review using CNN, LSTM and logistic regression.

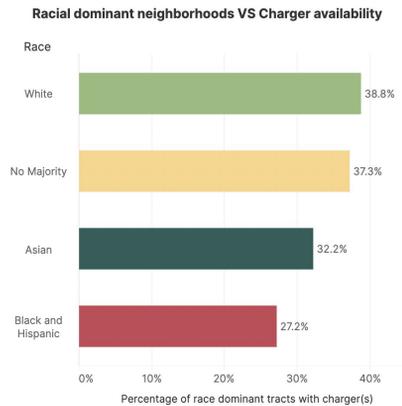
Sentiment Analysis on reviews on EV Charging Stations

- 57% of reviews on charging stations showed the charging spots being ICE'd (taken by internal combustion engine cars, usually gas cars).
- Functionality, availability and service time are the most discussed topics.
- Percentages of negative reviews are 50%, 23% and 22% regarding availability, functionality and service time.
- Nearly **half** (over 40%) of EV drivers have faced negative experiences during charging.

Here are some of our important findings. It is quite shocking to find out that nearly half of EV drivers have faced bad experiences when charging. Also, one thing to note is that a lot of the reviews showed the problem of ICE-ing, which means the charging spot was taken by gasoline powered cars. Gas station fueling service and real-time data are primarily classified as positive experiences by consumers in a similar use

Exploring Gaps in Equity

- White neighborhoods have greatest access to public charger access; Black & Hispanic the lowest
- Communities most vulnerable to environmental pollution also have least public charger access
- Multi-unit dwelling residents are in great need of more chargers
- Urban counties need more charging infrastructure to catch up with the high adoption rate



In this section, we evaluated gaps in charger access from an equity perspective.

(1) First, we grouped California census tracts by their dominant race to examine racial disparities. The bar chart suggests that about 39% of white dominant neighborhoods are equipped with public chargers, which is higher than racial minority groups. (followed by Asian, and Black & Hispanic neighborhoods.)

In case being asked: (Since black dominants tracts are very few (see [Table 1](#)), and followed a similar trend line to hispanic majority groups in charger access suggested by past research (Hsu & Fingerman, 2021), we combined Hispanic and Black as a new group, where hispanic population and black population altogether take more than 50% of the total population.)

(2) We further leveraged the CalEnviroScreen Score to measure communities' vulnerability to pollution effects. This metric considers environmental, health and socioeconomic factors together for identifying the disadvantaged communities. It turns out most disadvantaged communities, which fall into the fourth quartile in the bar chart, show the least access to both public Level 2 & DC fast chargers. (These communities have been targeted by the government.....)

(3) Moving forward, charger access also shows disparity across different housing types. It's hard to install home chargers in multi-unit housing if their building codes are not upgraded. Ideally, regions with more multi-unit dwelling residents should have

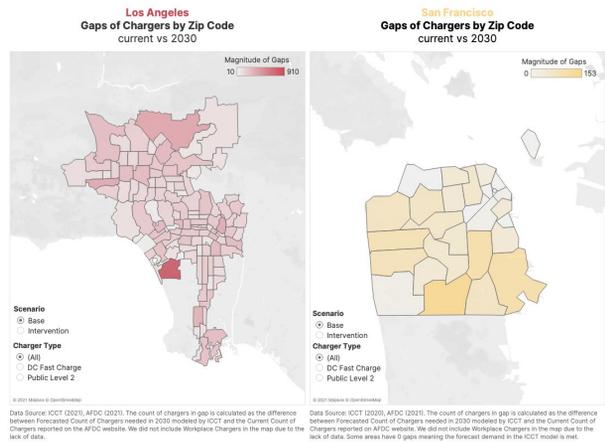
greater public charging deployment. We used a bar chart to visualize if such a trend holds in California. Green bars represent chargers per capita and orange dots represent percentage of multi-unit residency. Counties that are high in multi-unit dwelling residency didn't show any advantage in charger access than those lower in multi-unit residency. We highlighted those counties on the left that should have more public chargers in the future to meet the needs of their multi-unit housing residents, such as SF, LA and Alameda.

(4) Finally, we also found that urban counties, indicated by red dots, have higher number of EVs, but their infrastructure capacity need to catch up. As for the EV vs public charger ratio, most urban counties have greater than 40 EVs to share 1 charger. this confirms our findings in the previous chart, where these urban counties indeed need more chargers.

The identified gaps in equity are expected to assist policymakers to include disadvantaged and minority communities for achieving an equitable as well as large-scaled EV transition.

Exploring Gaps in Scale

- Gaps are big to have chargers needed for 2025 and 2030
- Transport policies making the charging infrastructure goals more attainable
- Mapping the gaps in base case and policy intervention case



After seeing the gaps in equity, we will move on to understand the gaps in scale, and it only makes sense to compare our status quo to the future. Since the situation varies in cities and counties, we select Los Angeles and San Francisco as our examples.

1) Gaps are big

First, we use waffle charts to show the progress as percentages of chargers needed in 2025 and 2030. We can see the big gaps will put a lot of pressure on cities to build more chargers faster. Especially in LA, currently the chargers we have is only 5% of chargers needed in 2030.

2) Transport policies can make the goals more attainable

So we want to ask: How can we close the gaps faster? Here are two ideas. First, accelerate the pace. Second, lower the bar.

The State Government has just proposed 1 billion dollar budget to facilitate EV charging infrastructure, and industry is also making promising progress. So, we believe the first box is checked.

For the second box -- lower the bar, there is actually some room to change.

We can use policies to push down the high demand of public chargers estimated in base case to reach the 100% new cars sales. In the chart, the length of the whole bar shows the demand in base case, meaning no policy interventions. Imagine these bars are pushed down by different policies to be

under the water if 0 on the y-axis is the water surface. The orange part is the remaining demand, and the green part is the reduction by policies. We should note that it depends on the setting of different cities, many other interventions can help reduce the high demand of public chargers and bring about sustainable benefits, such as reduce congestion, and encourage biking, walking and public transit uses.

1) Visualize the gaps on the map

Finally, let's take a look at the gaps by zip code against what we need in 2030. The intensity of color shows the magnitude of the gaps. We can compare the base case and the intervention case. We see that these policies are really effective in reducing charging needs.

(For this section, we would like to emphasize that sometimes it is not the more chargers the better. Policy makers should think comprehensively and aim to build just the right amount of infrastructure at the right places. We can gain many sustainable benefits in the long term and also save public resources for those in the greatest needs.)

Conclusions

EV transition will move fast, and no community should be left behind. Special attention should be paid to disadvantaged communities.

Not the more chargers the better. Think systematically and creatively, build just the right amount of infrastructure at the right places.

E-mobility is only part of the solution to a sustainable future. We look forward to a multi-modal transport system that is clean, efficient, equitable and accessible to all.

Q&A

Thank you!

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Please feel free to contact us
with any questions:
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This is the end. We would like to thank the guidance from our advisor Professor Marti Hearst, and the support from our family and friends. Thanks all! We're now open up for questions.