

# What is Happening at DC Fast Charging Stations? *Exploring User Experiences*



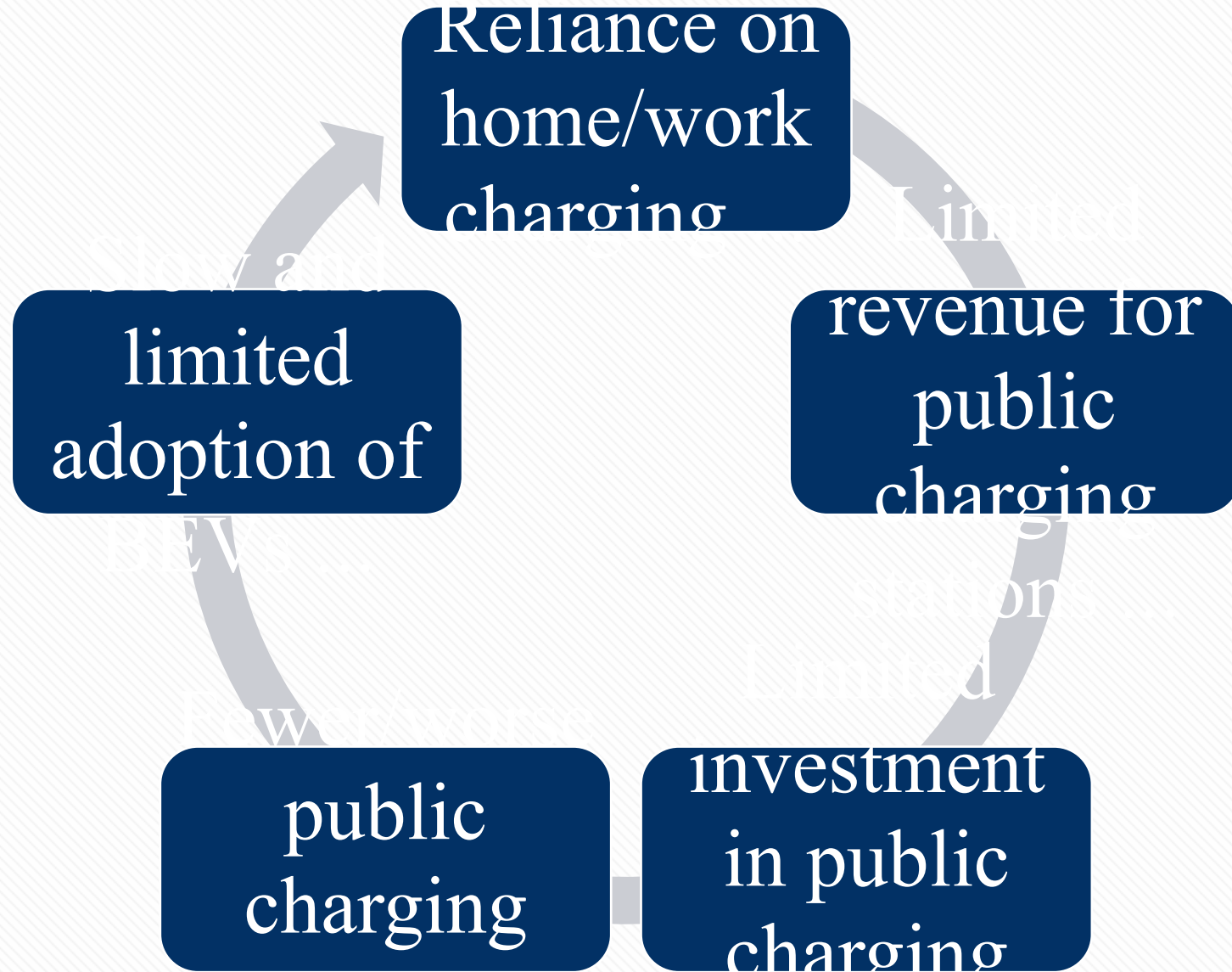
**UCDAVIS**  
Electric Vehicle  
Research Center



# Charging vs. Fueling

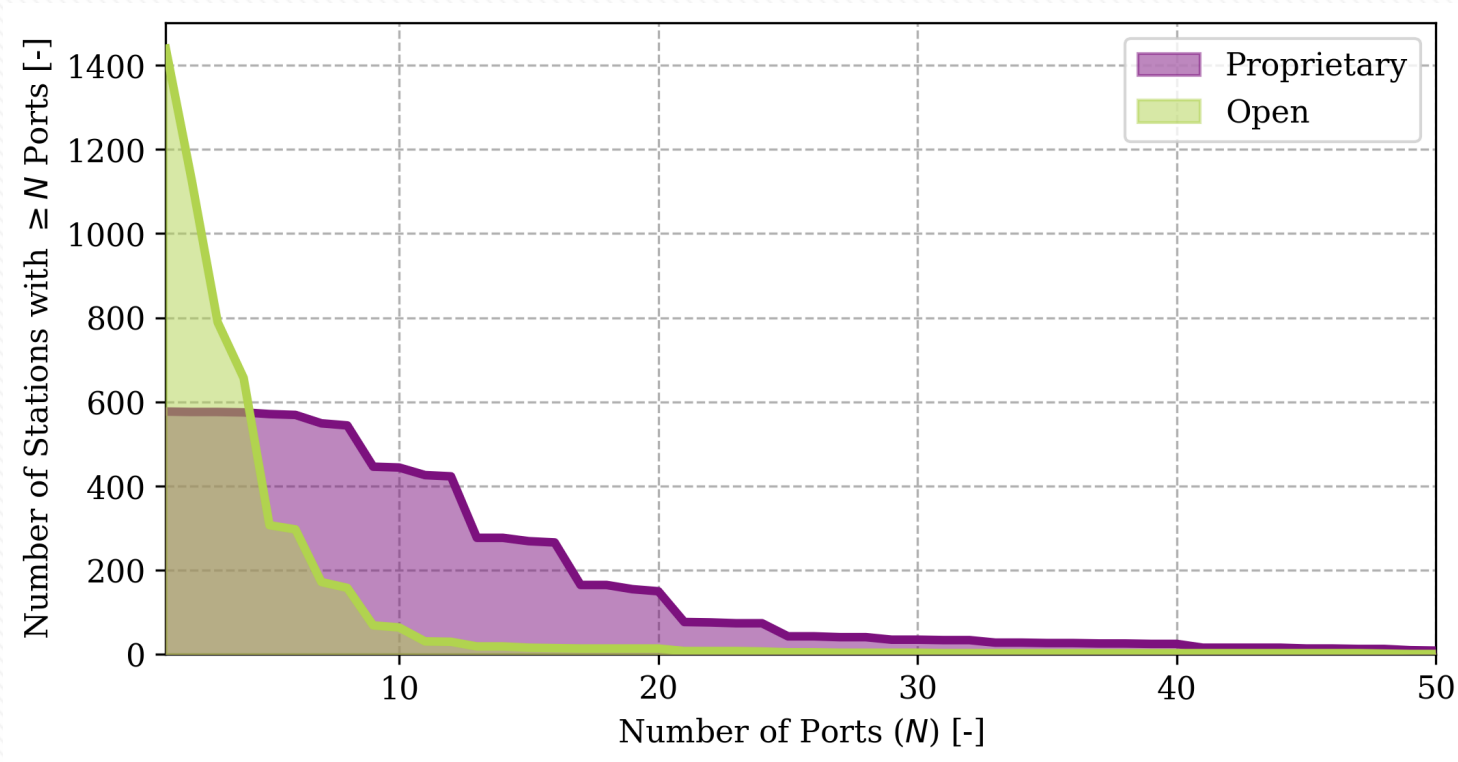
- Electric Vehicle Infrastructure is **new**, but it is not *de novo*
  - The vast majority of current BEV drivers have previously driven ICEVs
  - The vast majority of near-future BEV drivers are current ICEV drivers
  - Every aspect of the BEV experience will be interpreted in the context of the ICEV experience
- The primary BEV charging experience is the experience of charging at home
  - Most current BEV owners have access to home charging
  - BEV drivers with home charging experience a small convenience benefit over ICEV drivers
- Public BEV charging is an **inconvenience** to current adopters and a **deterrent** to future adopters

# Public Charging Doom Loop



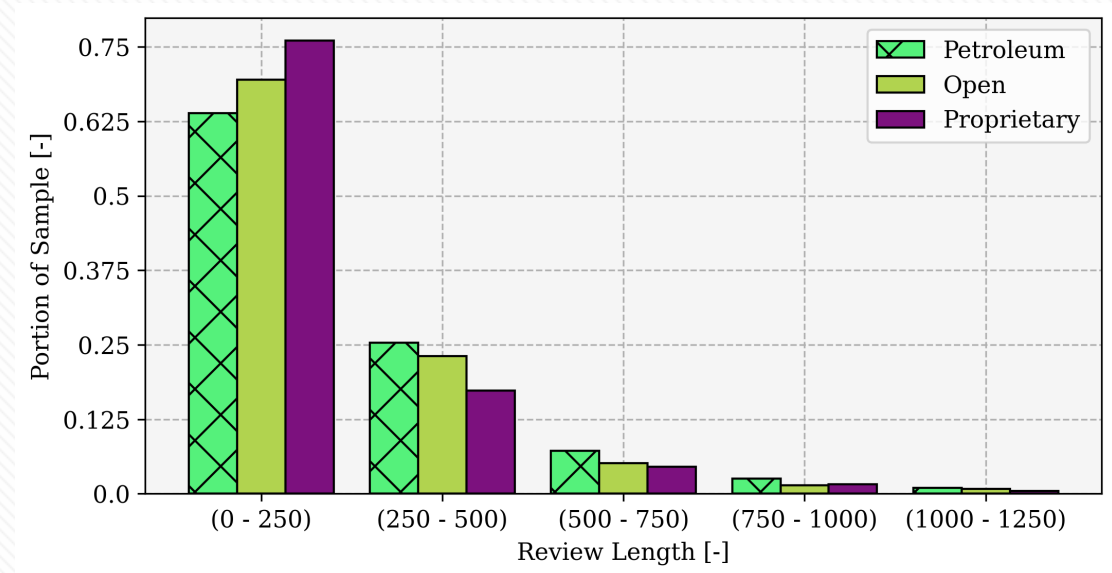
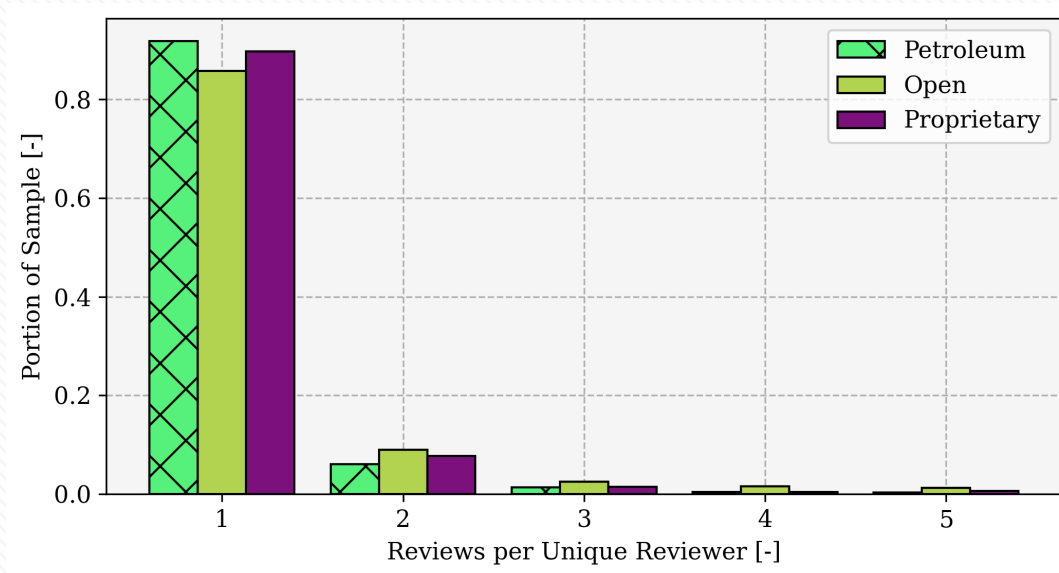
# Open Charging vs. Proprietary DC Charging

- Public charging networks have been heavily subsidized
  - Open networks are not manufacturer-specific and capture government subsidies
  - Proprietary networks are manufacturer-specific operate at a loss as parts of larger companies (Tesla, Rivian)



# The Dataset

- Reviews and ratings pulled from most Petroleum and DC Charging stations in California using Google Places API in early 2025
  - 51,346 text reviews from 44,777 unique reviewers
  - Google Maps API returns 5 most *relevant*\* reviews



# Labeling Reviews

- Reviews labeled using GPT-4o LLM via openAI API for Themes, Topics, and Sentiment
- Themes - Broad, deductively assigned experiential categories
- Topics - Specific experiences extracted inductively
- Sentiment - Overall attitude of reviews assigned deductively

# Example Review: Easy

**Text:** *“This supercharger is brand new and not much people are here charging. The charging speed is fast.”*

**Themes:** Availability / Access, Charging Performance

**Topics:** Fast Charging

**Sentiment:** Positive

# Example Review: Difficult

**Text:** *“Three Rivian Adventure Network chargers here but only one works at a time (despite three vehicles being plugged in). Talked to a great customer service rep who rebooted all three chargers to see if it would help. Sadly, it didn’t and we had to head back to the electrify america chargers, 10 miles away on 395 (which were all working great). Hope they get it fixed soon.”*

**Themes:** Functionality / Reliability, Customer Support, Location / Convenience

**Topics:** Charger broken, Good Support

**Sentiment:** Negative

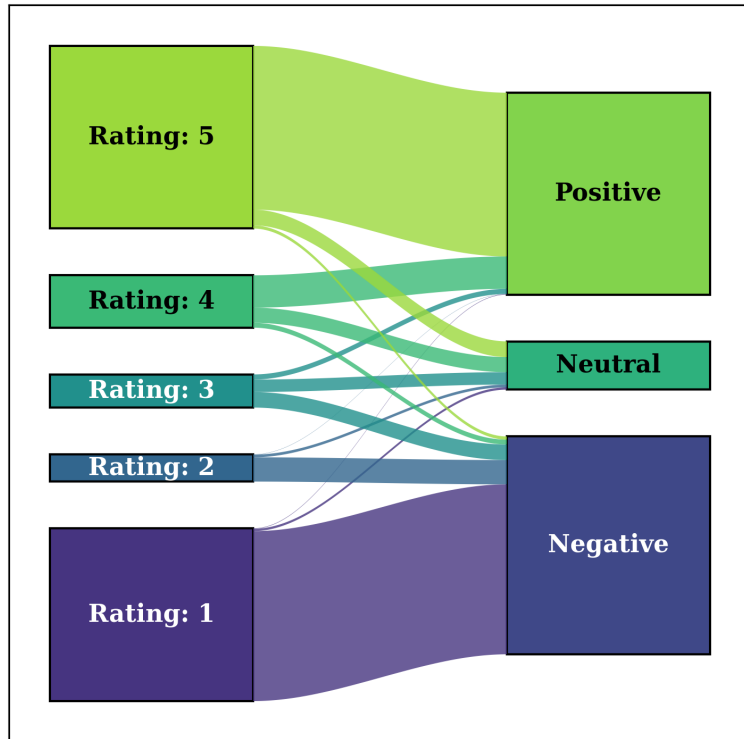
# Validation of Coding

- Coding was verified by statistical method to be at least **95% accurate** at **95% confidence**
- This was accomplished by leveraging the CDF of the Hypergeometric Distribution
- Evaluators were shown random labeled reviews and asked to determine if they were fully correct or not
- After **1,538** of **51,346** reviews were checked and **1,487** were deemed correct, the statistical threshold was met and the coding was accepted

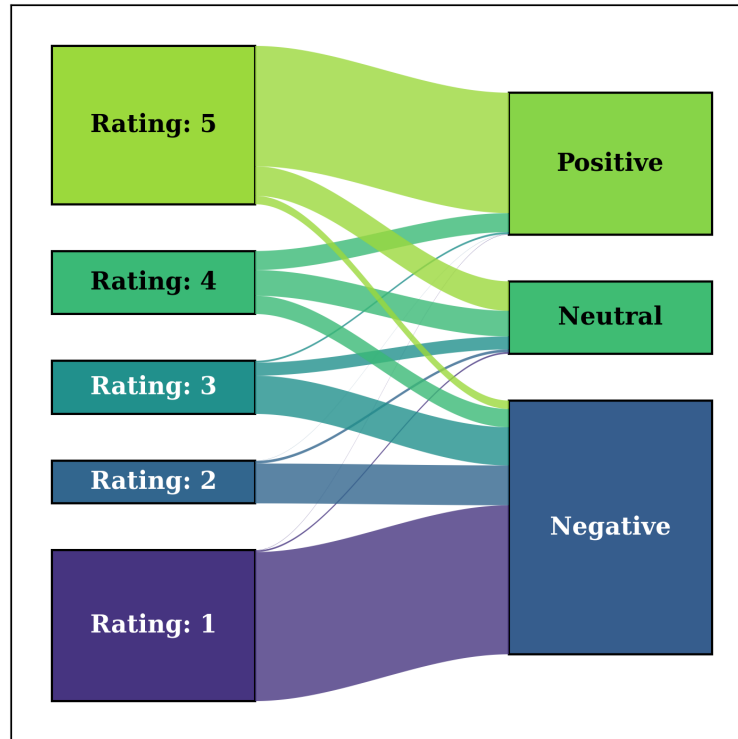
$$P(K \leq K^* \mid N, n, k) = 1 - \frac{\binom{n}{k+1} \binom{N-n}{K^*-k-1}}{\binom{N}{K^*}} {}_3F_2 \left[ \begin{matrix} 1, k+1-K^*, k+1-n \\ k+2, N+k+2-K^*-n \end{matrix}; 1 \right]$$

# Sentiment and Ratings

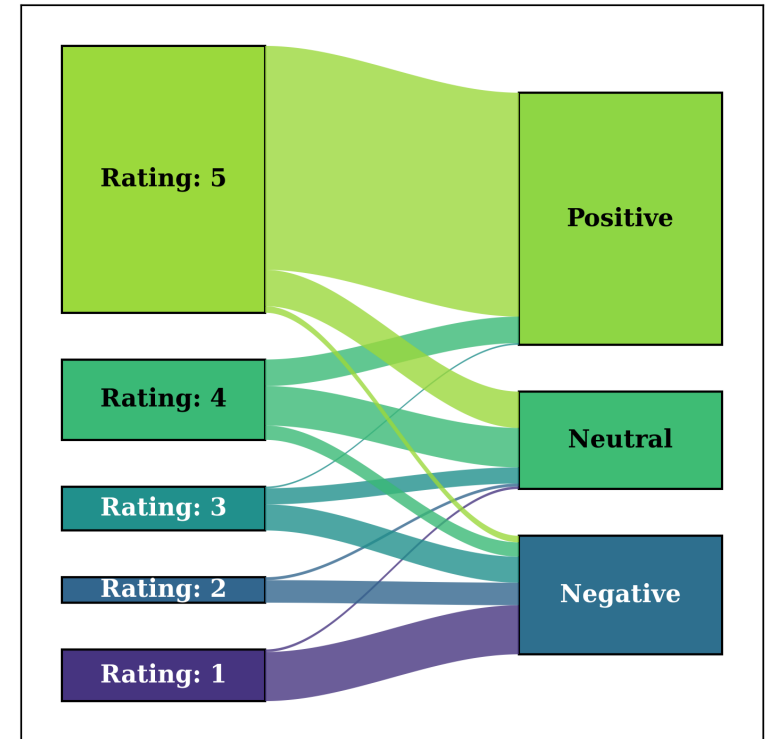
Petroleum Stations



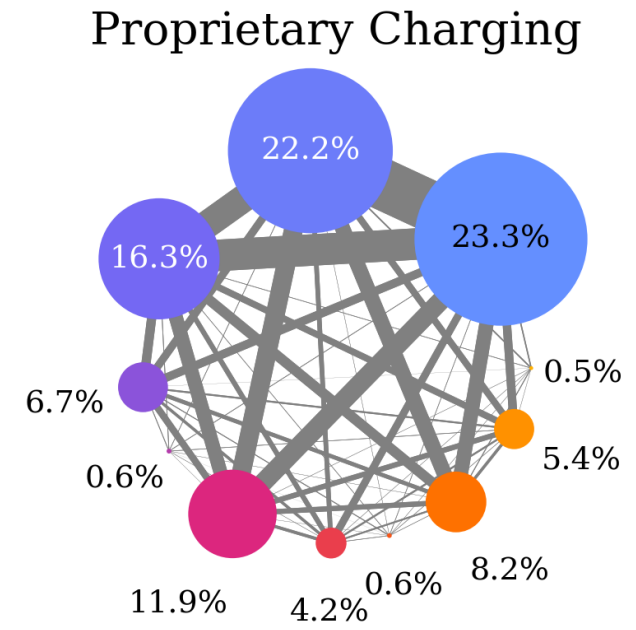
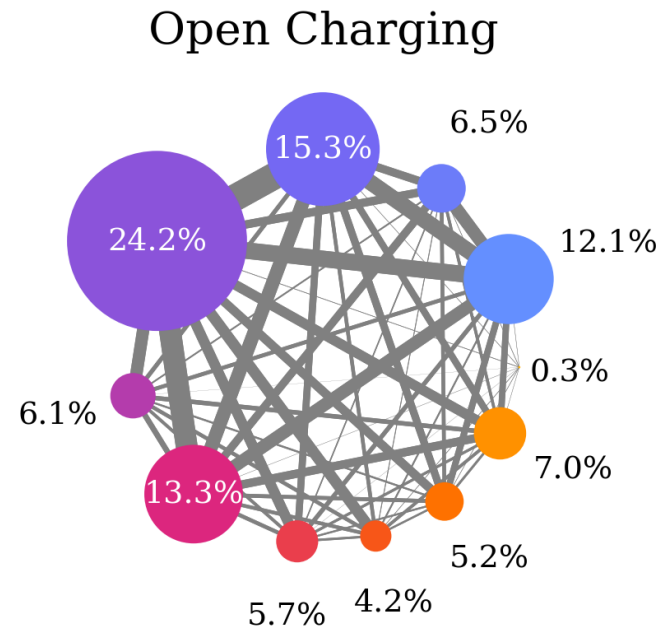
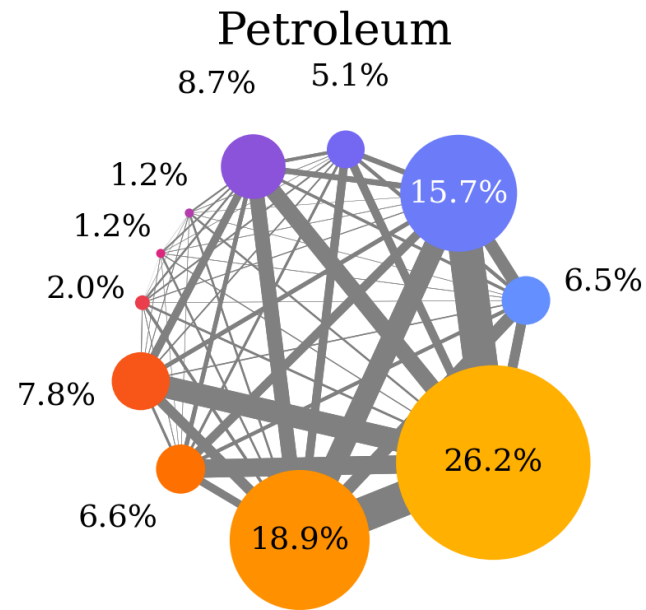
Open Charging Stations



Proprietary Charging Stations



# Thematic Occurrence



- Location / Convenience
- Amenities
- Availability / Access
- Functionality / Reliability

- Start-up / Authentication
- Performance
- Information / Visibility
- Customer Support

- Comfort / Safety
- Pricing / Billing
- Station Employees

# Themes/Sentiments Regression Analysis

- To better understand the relationship between themes and sentiments, an Ordinal Logistic Regression was performed on:
  - Occurrence of themes
  - Station characteristics
  - Station region
- Significant parameters (95% confidence) are displayed
  - Positive coefficients imply higher likelihood of positive sentiment over neutral and neutral over negative and *vice versa*

Parameter	Petroleum	Open	Proprietary
<b>Theme(s) in Review</b>			
Location / Convenience	0.8219	0.6879	0.7704
Amenities	0.5320	0.6551	0.6059
Availability / Access		-0.2014	
Functionality / Reliability	-0.4948	-0.5186	-0.3104
Start-Up / Authentication	-0.8184		
Performance	-0.2245	0.1308	
Information / Visibility	-1.1745	-0.6336	-0.6314
Customer Support	-0.2977	-0.8006	-0.6022
Comfort / Safety	-0.5862		-0.5016
Pricing / Billing	-0.0673	-0.2860	-0.3560
Station Employees	-0.0707		
<b>Station Characteristics</b>			
Capacity		1.9714	1.4415
Adjacent Stations		-0.2826	
Tract Median Income	-0.2177		
Tract Population Density			
Corridor		0.2010	
<b>Station Region (Compared to Los Angeles)</b>			
Northern Forest	0.3263		
Northern Valley	0.3742		
Sacramento			0.3287
Bay Area	0.1280		0.1446
Sierra	0.3574		0.3848
Central Coast	0.1748		0.4091
Central Valley	0.1670		
San Diego			
Southern Desert			0.1935

# Thematic Coefficients

- Overall similarity in regressed coefficients among station types
- Location/Convenience and Amenities receive large positive coefficients
- Negative Availability/Access coefficient for Open only
- Performance is negative for Petroleum, positive for Open, and not significant for Proprietary
  - Reflects variance in Open station performance
- Negative Station Employees coefficient for Petroleum only

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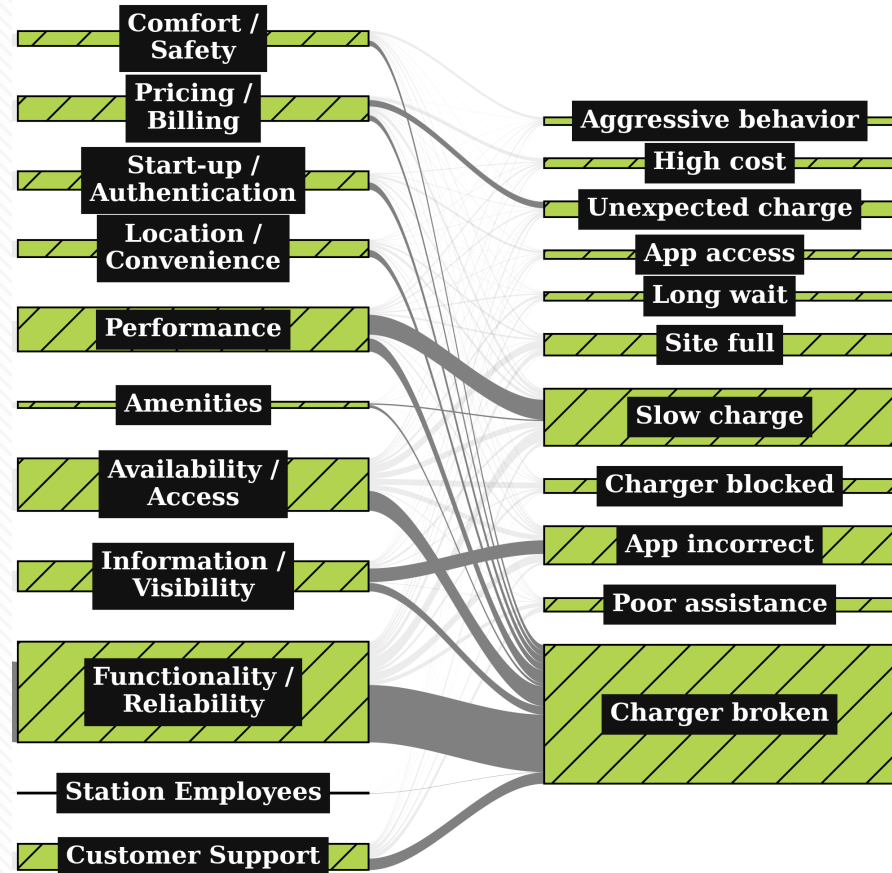
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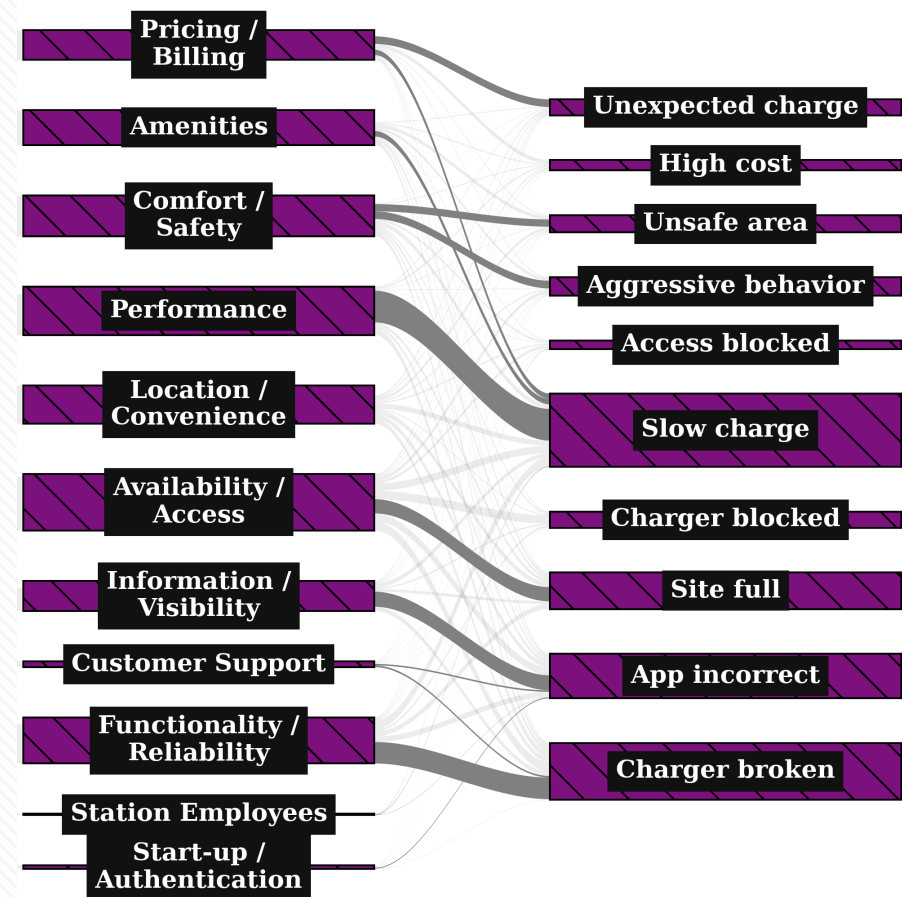
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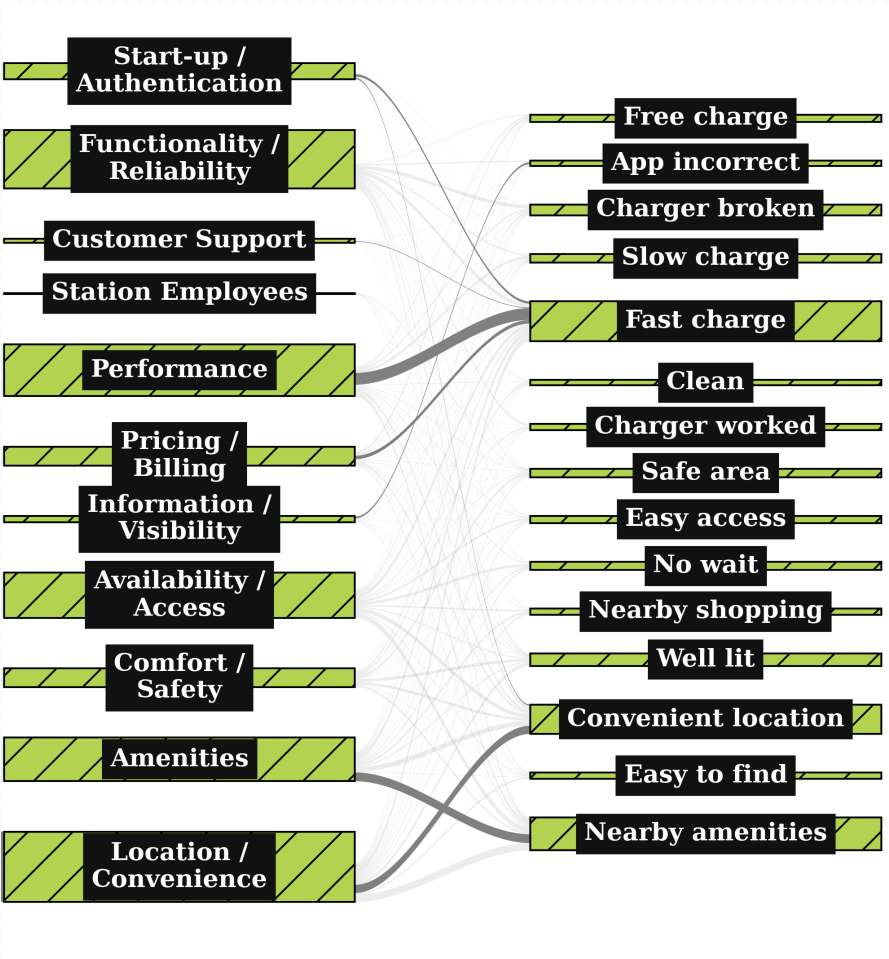


Open Charging Stations

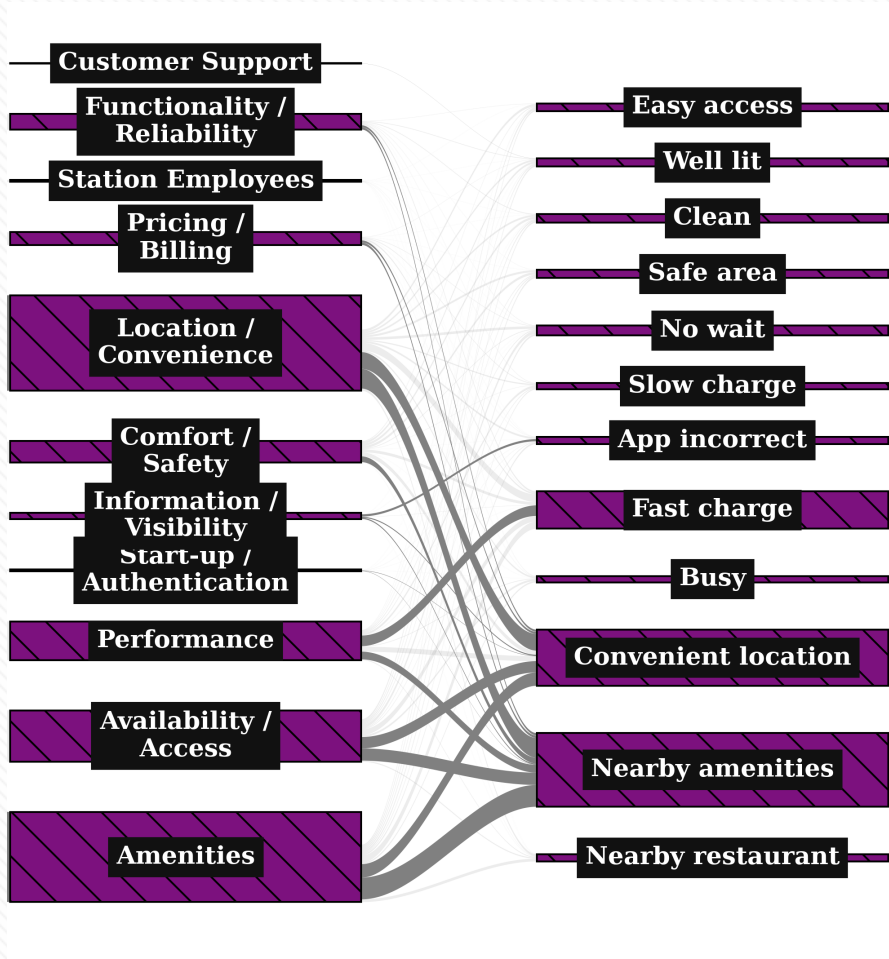


Proprietary Charging Stations

# Themes and Topics of Positive Reviews



Open Charging Stations



Proprietary Charging Stations

# Non-Thematic Coefficients

- In-station capacity improves review sentiment for charging stations, adjacent stations reduce review sentiment for Open charging stations
  - *Capacity is computed based on number of ports and port max power*
- Big corridor stations are the best reviewed Open charging stations
  - *Corridor stations are in rural areas and nearby major roads*
- **The above are very large coefficients**
- Substantial regional variation for Petroleum stations and Proprietary stations, no significant variation for Open stations

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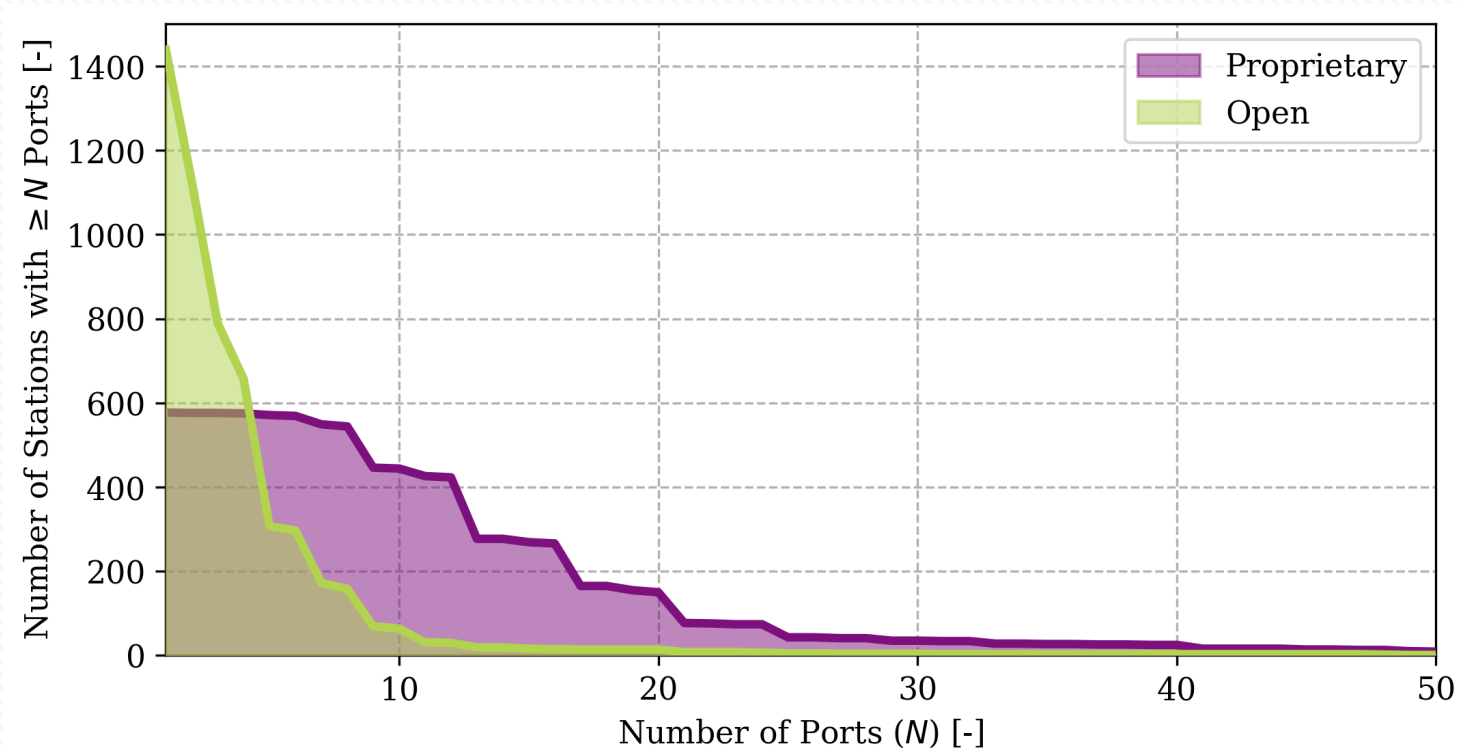
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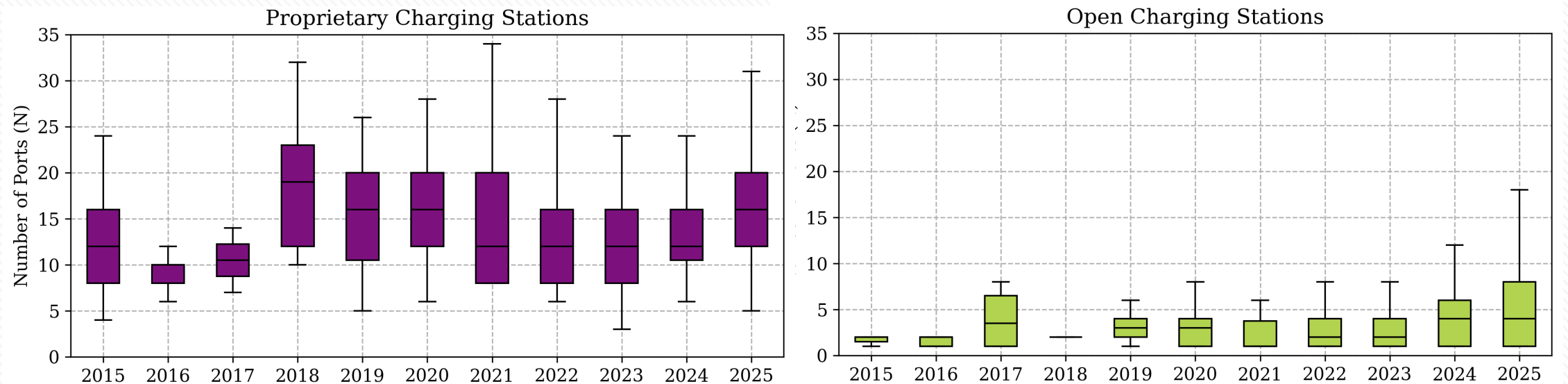
# Open Charging vs. Proprietary Charging (Again)

- Open charging networks consist of a larger number of smaller, and often adjacent, stations
- Proprietary networks consist of a smaller number of larger stations



# Maybe this is Changing?

In recent years Open networks have started to build larger stations while Proprietary networks have built medium sized stations



# Takeaways

- ICEV drivers don't really notice the fueling aspects of the experience unless something goes wrong
  - ICEV fueling is seen as a fundamentally different experience - but not necessarily a good experience
- There is a massive perception gap between Proprietary and Open charging stations
- Charger functionality issues are immensely frustrating to consumers and are prevalent among negative reviews
  - Reliability is clearly a larger issue at Open network stations, possibly due to ...
- All else being equal, higher-capacity stations receive better reviews
  - The presence of other options in an area leads to worse reviews
- Good (convenient) locations and good amenities also reliably lead users to leave reviews
  - Location quality and amenities are, often, linked for users