

MultiCampus Data Scientist/Data Engineer Boot Camp – Data Visualization Group Project

A Proposal for Improvement of Electric Vehicle Charging Stations and Traffic Volume in Interstate highway's Rest Area in South Korea

Sichan Kim

Team Name: Where is charging stations?

Member: Jooyeon Jeong, Minji Kim, Doeun Kim, Byungwoo Yoon, Sichan Kim

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References

Project Overview

- Introduce team members and roles
- Selecting a Project Topic

Introduce team members and roles



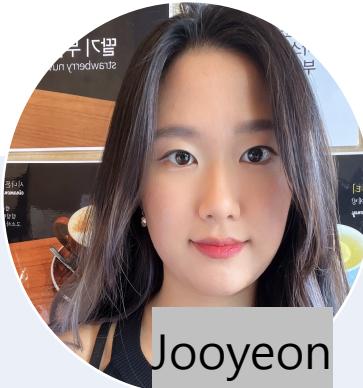
Minji

- ✓ Data analysis/visualization(charging station in rest area, error data)
- ✓ Organize materials and produce PPTs



Sichan

- ✓ Data analysis/visualization(interstate highway traffic, congestion by conzone)
- ✓ Organize the entire content
- ✓ Insight presentations



Jooyeon

- ✓ Data analysis/visualization(interstate highway traffic, congestion by conzone)
- ✓ Presenting an idea, organize data



Doeun

- ✓ Search data and materials
- ✓ Data Analysis/Visualization (Electric Vehicle Registration Status)
- ✓ Announcement



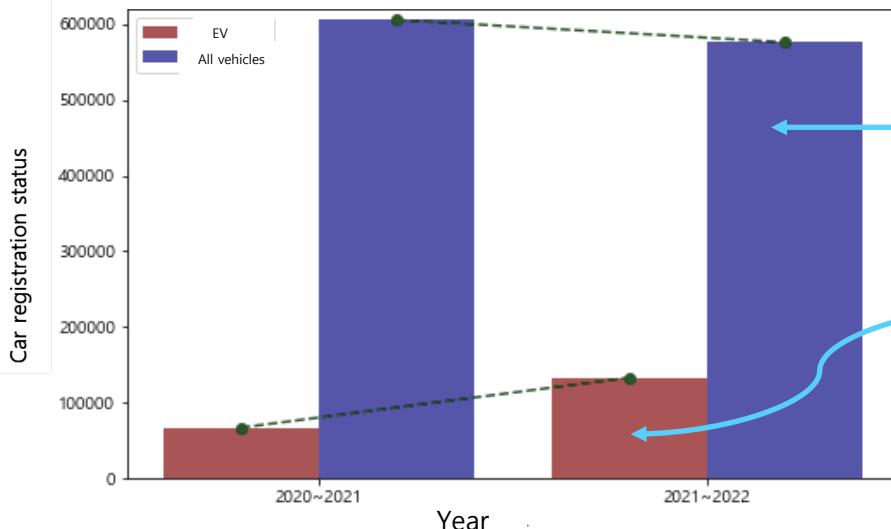
Byungwoo

- ✓ Data analysis/visualization(charging station in rest area)
- ✓ Organize the entire content
- ✓ Insight presentations

Selecting a Project Topic - selection background and problems recognition

1. 2020~2022 3 years of Electric Vehicle Market Growth

Comparison of year-to-year growth of EV compared to total vehicles



Total vehicle registrations
Even though it's getting
lower,

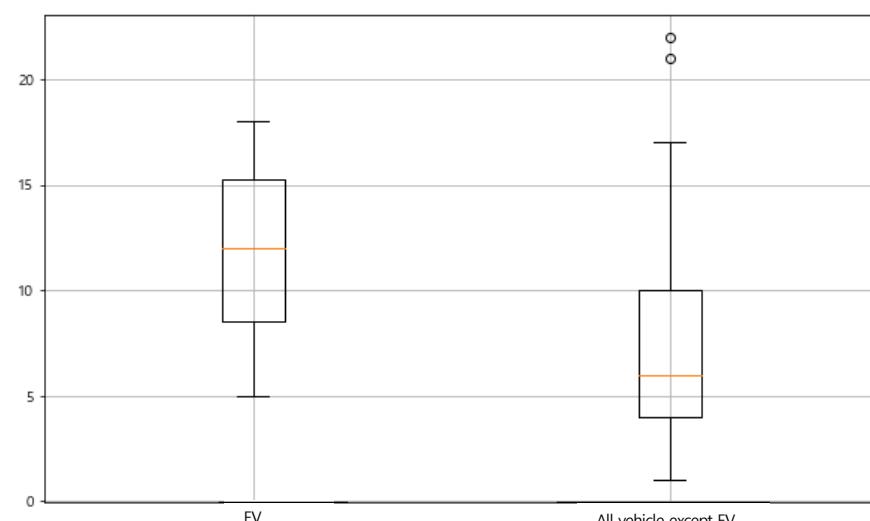
EV registrations
are getting higher

- ▶ EV production line
Photo from: TESLA



2. Factors that hinder the activation of electric vehicle utilization

Average vehicles forwarding period



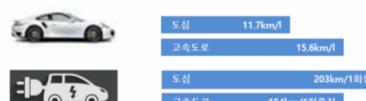
Average forwarding period
longer than normal vehicles
is hindering the fast
activation of the electric
vehicle market.

Subsidies are being
provided separately in each
city and province is also a
problem in the distribution
of electric vehicles by
region.

3. EVs fuel economy issues that still need improvement

24% decrease in mileage when driving on a highway in winter

△ 이한익 기자 | ◇ 승인 2021.02.10 14:40



내연기관차와 전기차 도심-고속도로 연비 비교 (자료제공=현대해상)

[뉴스웍스=이한익 기자] 전기차가 겨울철 고속도로를 달릴 경우 전기차 연비가 도심 주행 대비 24% 감소하는 것으로 조사됐다.

현대해상 교통기후환경연구소는 겨울철 주행거리 현장실험 결과 전기차는 고속도로 주행 때 도심 주행보다 연비가 평균 24%가량 줄어드는 것으로 나타났다고 10일 밝혔다. 반면 내연기관차는 고속도로 주행 때 연비가 33% 향상됐다.

전기차 운전자 150명을 대상으로 벌인 설문조사에서도 겨울철 영하 날씨에서 충전 후 주행거리가 평소보다 평균 33.4% 감소한 것으로 분석됐다.

EVs require an average of one charge per 154 kilometers on the highway. Especially in **winter**, the mileage is shorter because the fuel efficiency is lower.

However, due to the characteristics of roads in Korea with major highway lengths of 154km or longer, it can be inferred that charging must be done at highway rest areas when driving long distances.

Selecting a Project Topic

- selection background and problems recognition

4. Review of the actual use of EV user community members

Holidays and weekends would be more.

You'd better take the highway for a long distance and find a nearby fast charging station.

Everyone, the penetration rate of electric vehicles is still one digit Haha.

If it's over double digits, there'll be more hell.

In particular, the larger the battery capacity, the more likely it is to fill up an hour of charging.

As the number of electric cars increases, you should pay attention to the charging facilities at the rest area

Just collecting all the random chargers that were set up in the middle of the street...

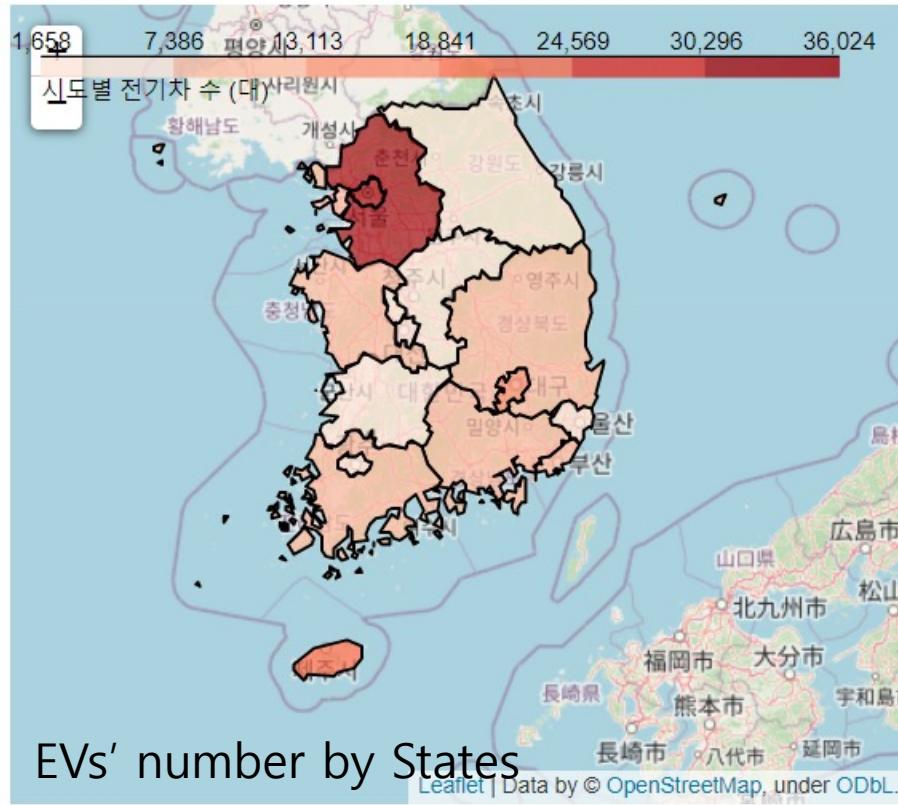
► There were many opinions that appropriate number of chargers was needed.



Long highway service area charging station
Waiting line causes inconvenience to users

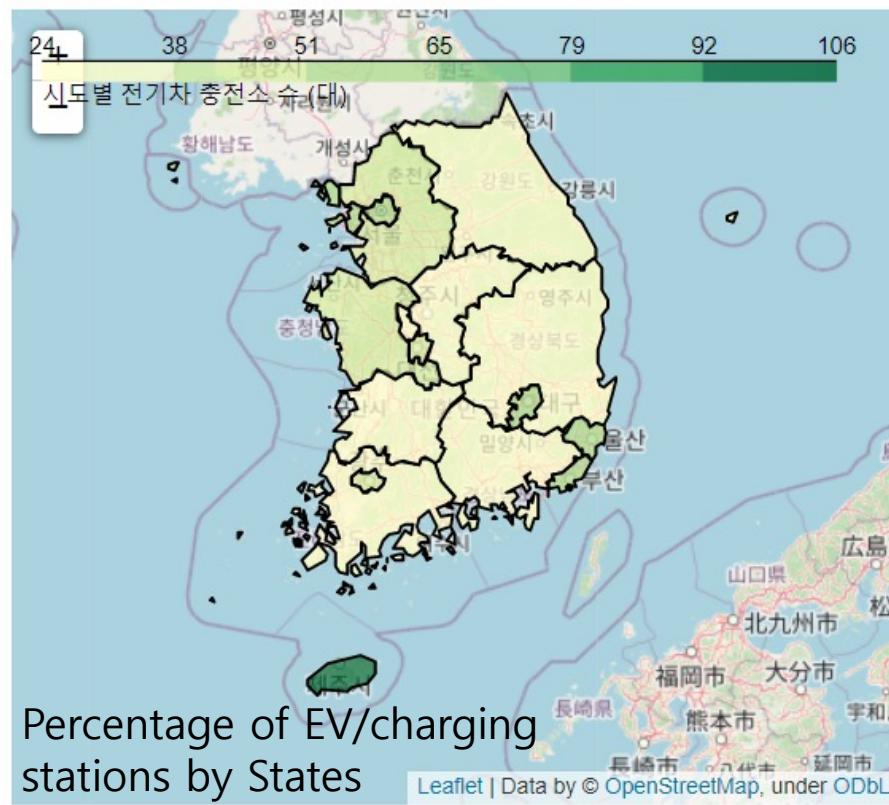
Selecting a Project Topic

- current status and background of electric vehicle penetration rate and electric/charging station ratio in each region in South Korea



- Areas with the best EV distribution: Metropolitan area
- In addition to the metropolitan area, Jeju island, Daegu city

Confirmed that electric vehicles are widely distributed in major metropolitan cities



- Intermediate points may normally have less charging station shortage compared to EVs visualization
- Possible **problems** with electric vehicles moving through midpoints in areas with many EVs

<Selecting a project topic>

- High growth rate of electric vehicles
- Low fuel efficiency for EVs – charging required for long-distance
- Unbalanced charging stations across the country
- Complaints and complaints about actual electric vehicle users' waiting times at highway charging stations
- >> **Investigate charging stations installed in highway service areas in consideration of the following problem**
recognition and the rising utilization of highway service stations due to upcoming holidays and the increase in electric trucks

Processing

- Data Collection
- Data Preprocessing
- Analysis Process

Data Collection

Material name (file type)	Sources	URL
2020 - 2022 July Automobile Registration Data Statistics (csv)	Public Data Portal - Ministry of Land, Infrastructure and Transport	https://www.data.go.kr/data/15024777/fileData.do
Korea Electric Power Corporation's Electric Vehicle Charging Station Charging Volume(csv)	Public Data Portal - Korea Electric Power Corporation	https://www.data.go.kr/data/15102510/fileData.do
Current status of subsidies for purchasing pollution-free vehicles	Integrated website for pollution-free vehicles	https://ev.or.kr/portal/localInfo
Fast Electric Vehicle Charging Station latitude and longitude(csv)	Public Data Portal - Korea Electric Power Corporation	https://www.data.go.kr/data/15102458/fileData.do
Electric vehicle charging station monitoring	Integrated website for pollution-free vehicles	https://ev.or.kr/evmonitor
January – July, 2002 Traffic by Conzone(csv)	Korea Expressway Public Data Portal	http://data.ex.co.kr/portal/fdwn/view?type=ETC&num=78&requestfrom=dataset#
Current status of electric vehicle subsidy closing(csv)	EV-Infra	https://ev-infra.co.kr
Estimated production day by vehicle for 06/08/22(csv)	Lotte Rent-a-Car New Vehicle Direct	https://direct.lotterentacar.net/customer/notice.do?mnCd=MNCD06008
Congestion frequency by conzone per day(csv)	Korea Highway Corporation Highway Public Data Portal	https://www.data.go.kr/data/15045664/fileData.do http://data.ex.co.kr/portal/fdwn/view?type=ETC&num=S0&requestfrom=dataset

Data Preprocessing - Extracting and grouping required columns from circular data

Original Data

집계년 월	집계시 분	VDS_ID	기점종점방 향구분코드	노선번 호	지점이 정	도로이 정	평균교 통량	평균속 도	혼잡빈 도수	차로 번호	콘존명	콘존 길이
0 202201	00:00	0010VDE00100	E	10	1.40	0.20	3	100.36	0	1	구서IC-영 라IC	1.82
1 202201	00:00	0010VDE00100	E	10	1.40	0.20	9	87.75	0	2	구서IC-영 라IC	1.82
2 202201	00:00	0010VDE00100	E	10	1.40	0.20	5	74.05	0	3	구서IC-영 라IC	1.82

(Original) Congestion frequency file:

Group time in minutes in hours, proceed with zone name grouping,

Conzone length and route number are unique values, so set as is

Re-arrange results divided by subsequent hour by time again

노선번호	도로명	이정	X좌표값	Y좌표값	Route Name
0 10	경부선	0.0	35.246578	129.093207	
1 10	경부선	0.1	35.247249	129.093941	
2 10	경부선	0.2	35.247919	129.094676	

(Original) latitude file:

Express coordinate information by road name and conzone name
combining two files with a common value of route number/modification

Data after preprocessing

index	집계 시분	콘존명	집계년 월	노선번 호	지점이정	도로이 정	평균교통 량	평균속도	혼잡빈 도수	차로번 호	콘존길 이	도로명	시간대
0 0 0	88JC-김포공항IC	202201.0	1300	33.910000	35.4	3.305556	94.554167	0.0	2.000000	2.1	인천국제 공항선	00시 ~05시	
1 1 0	공항신도시JC-공 항입구IC	202201.0	1300	4.728571	2.8	4.321429	108.562738	0.0	2.285714	3.4	인천국제 공항선	00시 ~05시	
2 2 0	공항신도시JC-신 불IC	202201.0	1300	0.680000	2.8	1.395833	99.931458	0.0	2.500000	2.8	인천국제 공항선	00시 ~05시	

집계 시분	콘존명	집계년 월	노선번 호_x	이정_x	평균교통 량	평균속도	혼잡빈도 수	차로 번호	콘존길 이	노선번호 이정	도로명	x좌표값	y좌표값
0 0	88JC-김포 공항IC	202201.0	1300	35.4	3.305556	94.554167	0.000000	2.0	2.10	130035.4	인천국 제공항 선	37.588743	126.827009
1 0	가락IC-서 부산IC	202201.0	1040	12.7	7.050000	102.673292	0.050000	2.5	5.58	104012.7	남해제2 지선	35.165281	128.891819
2 0	가락IC-서 부산TG	202201.0	1040	12.7	0.000000	0.000000	0.000000	2.5	2.00	104012.7	남해제2 지선	35.165281	128.891819

Route number

Data Preprocessing

- Use the selenium package to crawl and extract the required information

1) Above longitude not in raw data

	Name of Rest Area	Address
0	이인휴게소(천안방향)	충청남도 공주시 이인면 논산천안고속도로 32
1	예산휴게소(당진방향)	충청남도 예산군 신양면 당진영덕고속도로 33 (서계양리)
2	안성휴게소(부산방향)	경기도 안성시 원곡면 경부고속도로 365
3	경주IC휴게소	경상북도 경주시 울동 64-1
4	입장휴게소(서울방향)	충청남도 천안시 서북구 입장면 연곡길 407
5	영천휴게소(대구방향)	경상북도 영천시 임고면 금대리
6	충주휴게소(양평방향)	충청북도 충주시 중앙탑면 중부내륙고속도로 230-1
7	외동휴게소(울산방향)	경상북도 경주시 외동읍 상석길 58-70 (석계리)
8	매송휴게소(서울방향)	경기도 화성시 매송면 서해안고속도로 316
9	섬진강휴게소(부산방향)	전라남도 광양시 진월면 섬진강매화로 141



2) For statement using selenium

```
# 입력창에 주소전달
try:
    input_values = driver.find_element(By.XPATH, '//*[@id="input_juso"]')
    input_values.send_keys(addr)
    time.sleep(0.3)

    # 실행 입력
    serach_click=driver.find_element(By.XPATH,'//*[@id="btnSch"]')
    driver.execute_script('arguments[0].click();',serach_click)
    time.sleep(0.5)

    # 위경도값
    x_y_values=driver.find_element(By.XPATH, '//*[@id="insert_data"]',value)
    xval = x_y_values.split(',')[0][3:]
    yval = x_y_values.split(',')[1][4:]

    # 입력값 지우기 함수호출
    clear_text(input_values)

    #리스트에 추가
    xvalues.append(xval)
    yvalues.append(yval)
except:
    xvalues.append("null")
    xvalues.append("null")
```

4) Return address to latitude and longitude

Name of Rest Area	Address	Latitude	Longitude
이인휴게소(천안방향)	충청남도 공주시 이인면 논산천안고속도로 32	36.352419	127.069040
낙동강의성휴게소(하행)	경상북도 의성군 단밀면 낙정리	37.256056	128.048026
삼국유사 군위휴게소(서울방향)	경상북도 군위군 부계면 치산호령로 989-23	36.079387	128.696749
삼한휴게소	충청북도 음성군 생극면 중원대로	37.055378	127.602160
고창고인돌휴게소(시흥방향)	전라북도 고창군 고창읍 서해안고속도로 80 (신월리)	35.460752	126.672843
문경휴게소(마산방향)	경상북도 문경시 중부내륙고속도로 173	36.620018	128.150576
청도새마을휴게소(부산) 하행	경상북도 청도군 청도읍 하지길 59-49	35.595136	128.767237
여주휴게소(강릉방향)	경기도 여주시 가남읍 여주남로 722	37.237883	127.569572
오수휴게소(광양방향)	전북 임실군 오수면 순천완주고속도로 73	35.540966	127.310324
마장복합휴게소	경기도 이천시 마장면 중부고속도로82	37.261879	127.409471
예산휴게소(당진방향)	충청남도 예산군 신양면 당진영덕고속도로 33 (서계양리)	36.619782	126.845793
대천휴게소(시흥방향)	충청남도 보령시 주교면 서해안고속도로 200 (주교리)	36.374370	126.558040
오수휴게소(전주방향)	전라북도 임실군 오수면 순천완주고속도로 74	35.540251	127.311601
예산휴게소(대전방향)	충청남도 예산군 신양면 당진영덕고속도로 34	36.622694	126.840712
화서휴게소(상주방향)	경상북도 상주시 화서면 터길길 51-25	36.552066	126.579946
그의휴게소(조치원방향)	경상북도 규리군 규리읍 경북대로 4082	36.265679	128.576669



3) Raw latitude crawling

제작/전환 결과
입력 충청남도 공주시 이인면 논산천안고속도로 32
정제 충청남도 공주시 이인면 논산천안고속도로 32 (이인리, 이인상행휴게소)
전환 충청남도 공주시 이인면 이인리 4
우편번호 32607
좌표 X : 127.069040, Y : 36.3524192

※ 주소전환은 대표지번을 기준으로 전환됩니다.
※ 위 좌표는 WGS-84 좌표계입니다.
※ 지금 실행하신 전환내용은 저장되지 않습니다.

Dawul 주소전환

주소전환 도로명주소판 서비스안내 이용안내

실행

닫기

Dawul ©

Data Preprocessing

- Extract and refine only the heat you need to create new data

```
final_df_2020_1 = df[df['충전소명'].str.contains('휴게소|쉼터')]
```

```
final_df_2020_1.to_csv('./data/2020_1data.csv')
```

```
final_df.info()
```

```
charge_min = list(final_df['충전분'])  
charge_min
```

...

```
index1 = final_df[final_df['충전분']<=3].index  
pprint(index1) # 충전시간이 3분 이하인 행의 인덱스 추출
```

...

```
index2 = final_df[final_df['충전분']>=3].index  
pprint(index2) # 충전시간이 3분 이상인 행의 인덱스 추출
```

...

```
error_df1 = final_df.drop(index2)  
# error_df1 # 충전분이 3분 이하인 데이터만 포함(충전시간 확인X)한 데이터프레임  
index3 = error_df1[error_df1['충전시간']>0].index  
error_df = error_df1.drop(index3)  
error_df # 전체 충전시간이 0시간 3분 이하인 데이터만 포함한 데이터프레임
```

From Raw data with charging records at nationwide charging stations,

1) Find and store only charging stations located within highway rest areas including 'rest areas'

2) Indexing rows with a 'charging time' of 3 minutes or less

3) Conversely, separate indexes of rows with a 'charge' of more than 3 minutes are extracted (This data is divided into charging time and minutes)

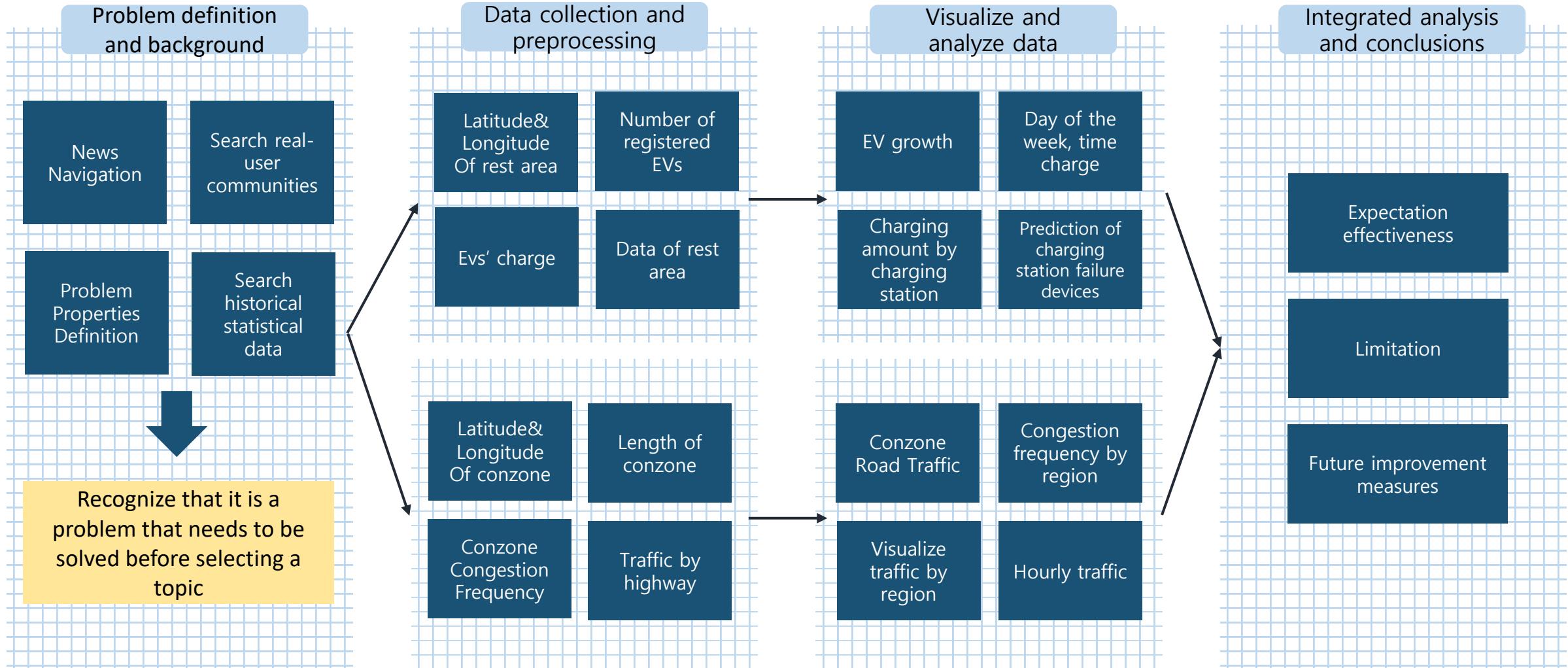
4) It erases data that has more than 3 minutes of charge

Extract only 'N hours (3>=) minutes' data

5) Finally, it erases data that has a charging time of more than zero, leaving only data that has a total charging time of less than 0 hours and 3 minutes to generate charging error data

6) Subsequently, all the quarterly data are grouped together into three years' worth of data

Analysis Process



Visualize and analyze data

- Average traffic volume by highway route and average congestion frequency by conzone
- Time Series Analysis of Congestion Frequency by Highway Route/Conzone
- Correlation between Conzone Length and Traffic Volume
- Correlation between Traffic and Charging
- Status of Charging Stations in highway Service Stations in Korea
- Charging error data

Visualize and analyze data - Average traffic by highway route

< ► Average traffic data by highway (by route/section) >

The Honam Line and Yeongdong Line are the most traffic,

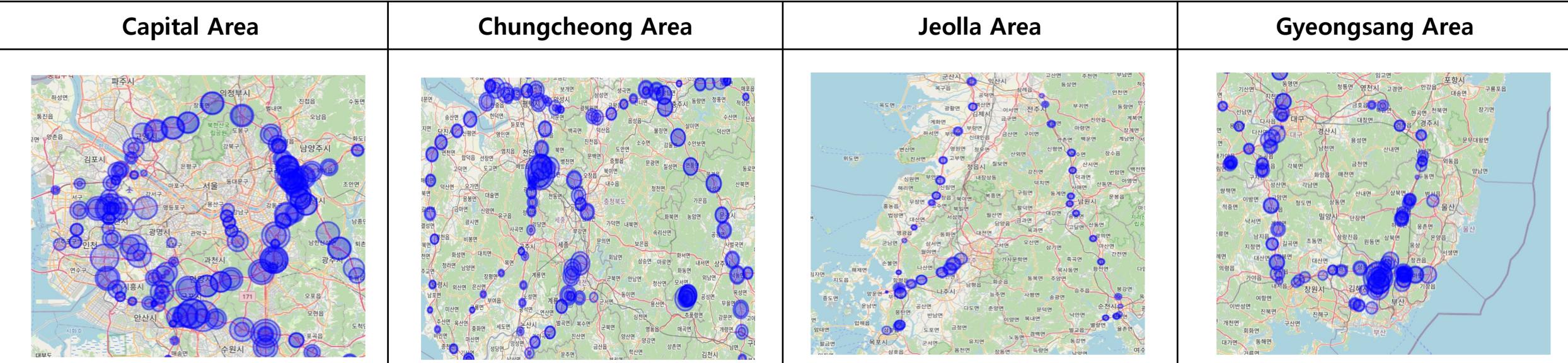
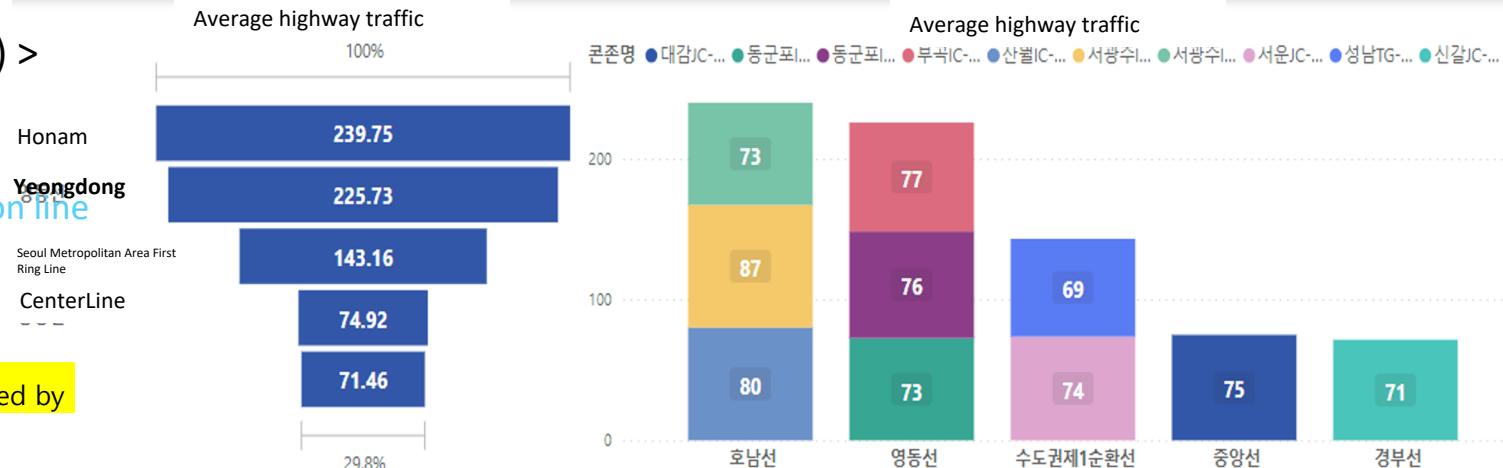
The frequency of congestion is **the highest on the first circulation line**
in the metropolitan area.

(Check the congestion frequency by conzone on the next page)

* Congestion frequency: Number of vehicles experiencing congestion (provided by Korea Highway Corporation)

< ▼ Visualized data by dividing the total traffic volume by region>

: Results show high traffic near large cities, major regional cities and airports



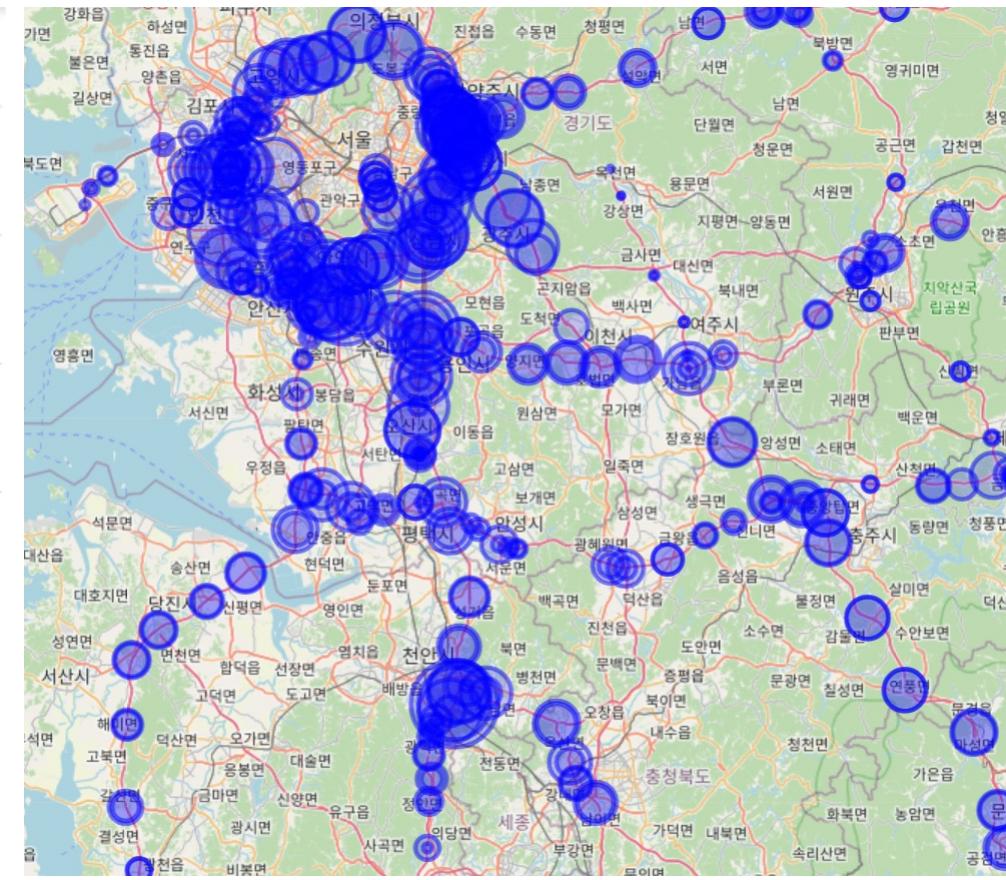
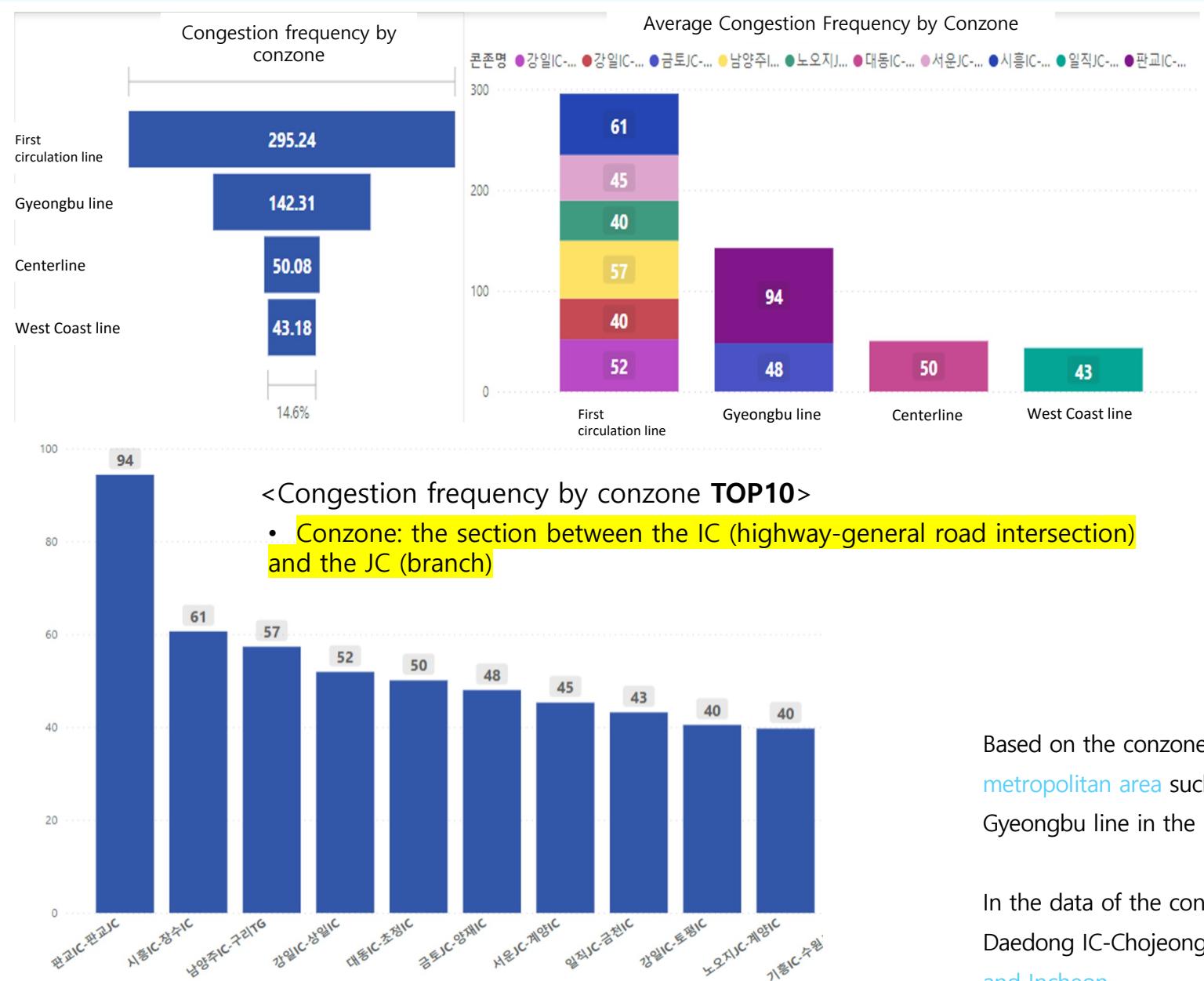
Pangyo, Gimpo, Bucheon, Incheon,
Guri, Gunpo

Pyeongtaek, Cheonan, Chungju,
Daejeon, Jecheon

Gwangju, Hampyeong, Mokpo

Busan, Daegu, Gimhae Airport

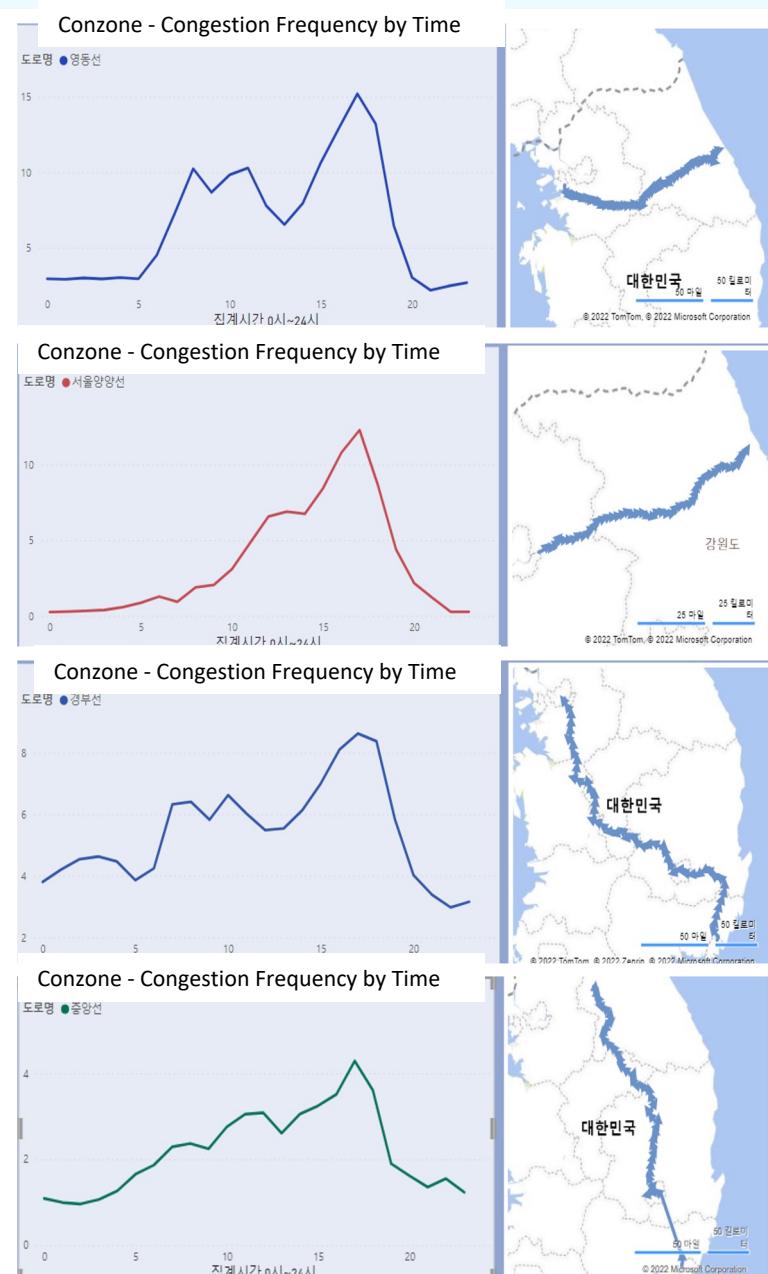
Visualize and analyze data - Average Congestion Frequency by Highway Conzone



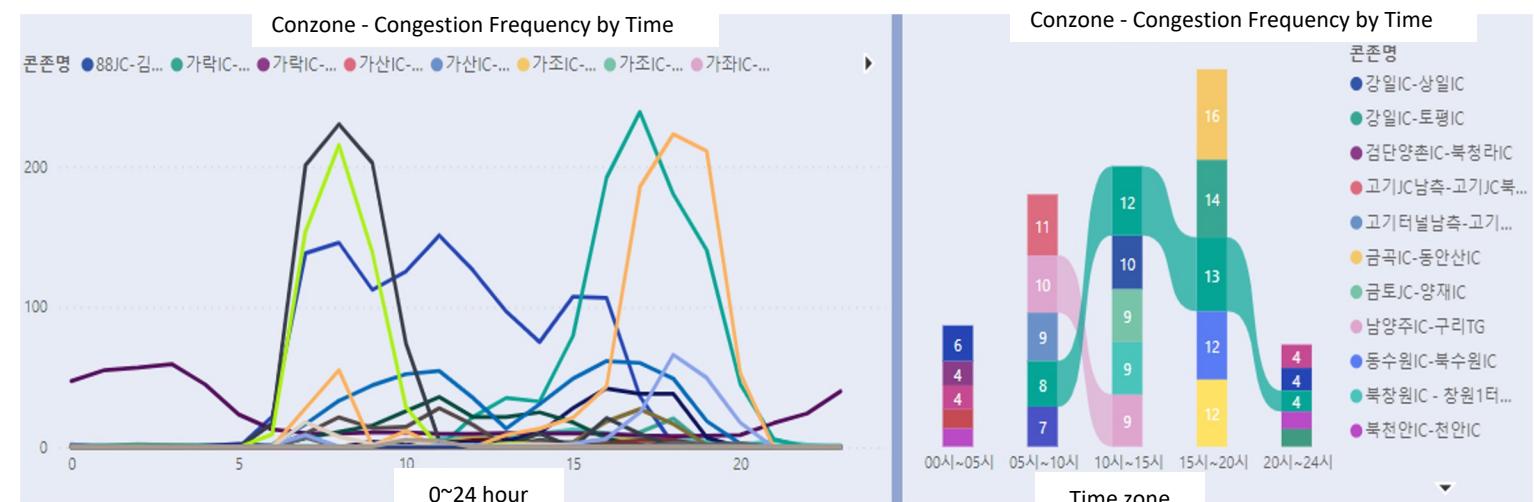
Based on the conzone, it can be seen that the frequency of congestion is high in the metropolitan area such as Pangyo, Namyangju, and Yongin, including the first ring line and Gyeongbu line in the metropolitan area.

In the data of the congestion frequency TOP 10, it can be confirmed that all nine places except Daedong IC-Chojeong IC (Kimhae, Gyeongnam) are metropolitan areas in Seoul, Gyeonggi-do, and Incheon.

Visualize and analyze data - Time Series Analysis of Congestion Frequency by Highway Route/Conzone



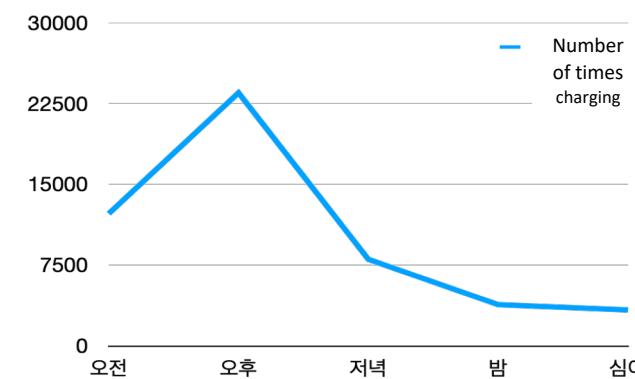
Traffic Analysis by Time Series Visualization by Highway Route/Conzone to Analyze Traffic Patterns
>>> Except for the Gyeongin Line, it is increasing more in the afternoon than in the morning.



Pangyo IC-Pangyo JC (Pangyo-dong, Seongnam-si, Gyeonggi-do): High congestion frequency continuously from 05:00 to 24:00
Namyangju IC-Guri TG (Namyang-si, Gyeonggi-do)Guri-si, Gyeonggi-do: Top congestion frequency from 05 to 15
Meat JC South, Meat Tunnel (Suji District, Yongin-si, Gyeonggi-do): The phenomenon of being crowded during the morning rush hour
Kangil IC - Sangil IC (Gangdong-gu, Seoul): Many users between 08:00 and 18:00
Kangil IC – Topyeong IC, Meat JC North (Gangdong-gu, Seoul, Guri-si, Gyeonggi-do, Yongin-si, Gyeonggi-do): The phenomenon of being crowded during the evening rush hour

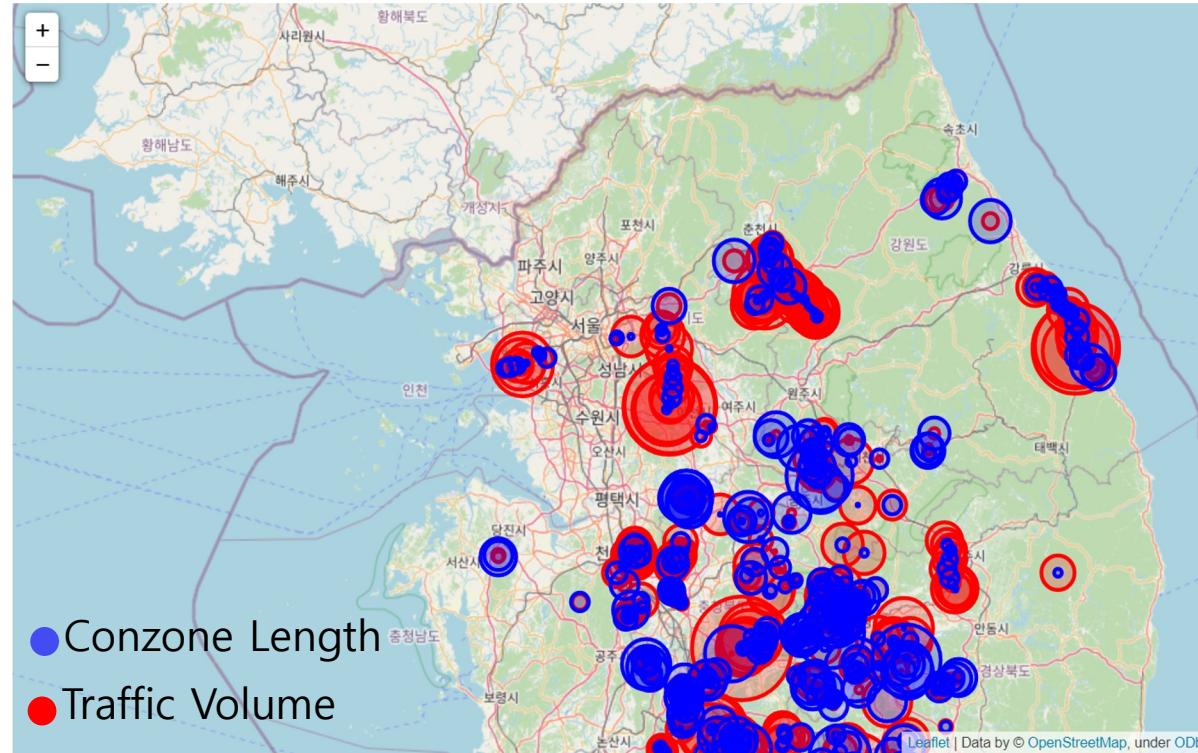
Metropolitan area, rush hour congestion

Similar to the above data, 70% of the total charge is concentrated during the morning and afternoon hours (07-18:00)



Time zone	Number of times of charging
A.M.	12289
P.M.	23512
Evening	8049
Night	3842
Dead of night	3352

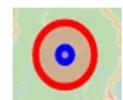
Visualize and analyze data - Correlation between Conzone Length and Traffic Volume



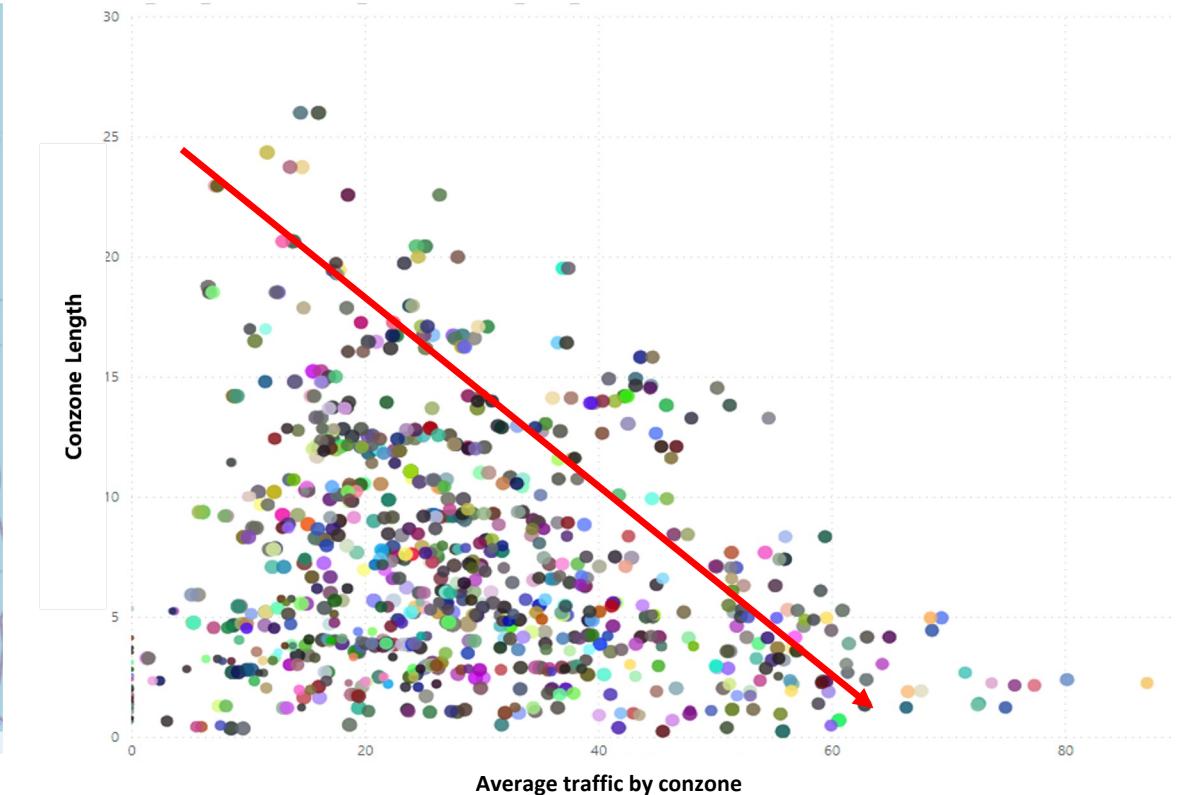
● Conzone Length
● Traffic Volume

While analyzing highway data visualization data,
Find that the sizes of the red and blue circles are inversely proportional as follows.

This means that it is close to an inversely proportional relationship between the length of the cone and the traffic volume



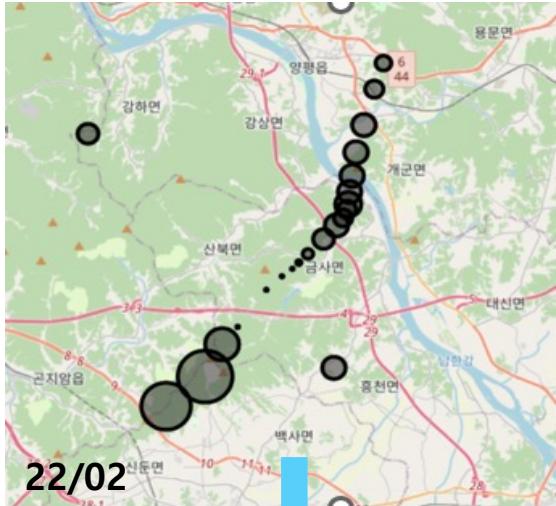
Therefore, areas with large red circles and small blue circles can be interpreted as having a short cone-zone length but high usage.



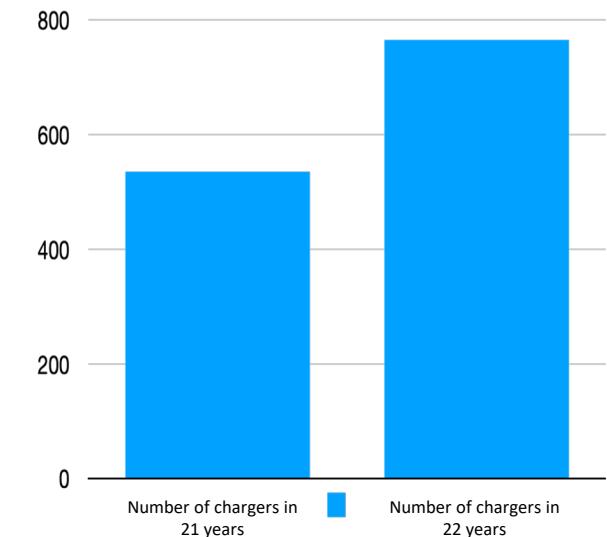
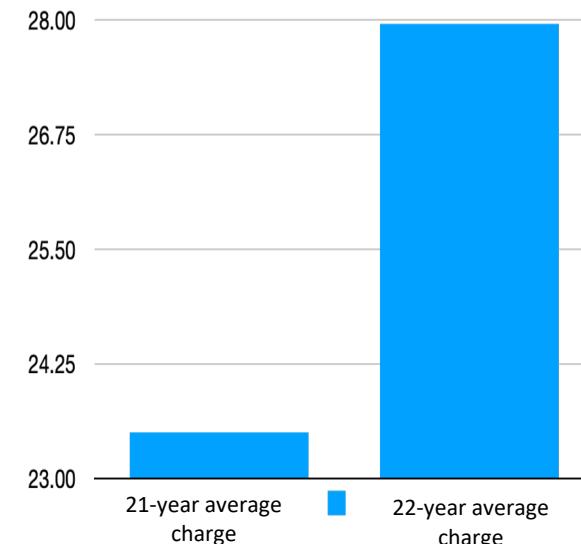
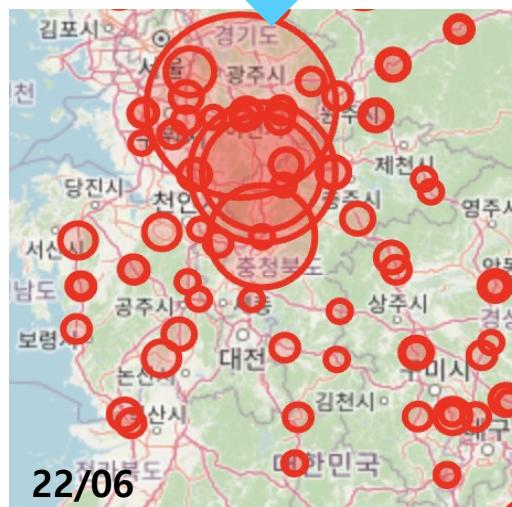
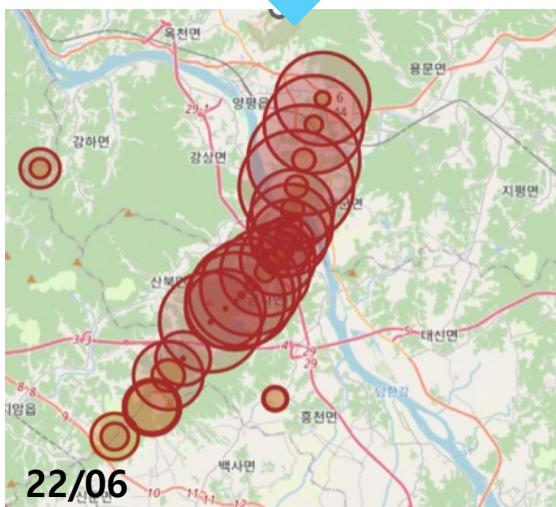
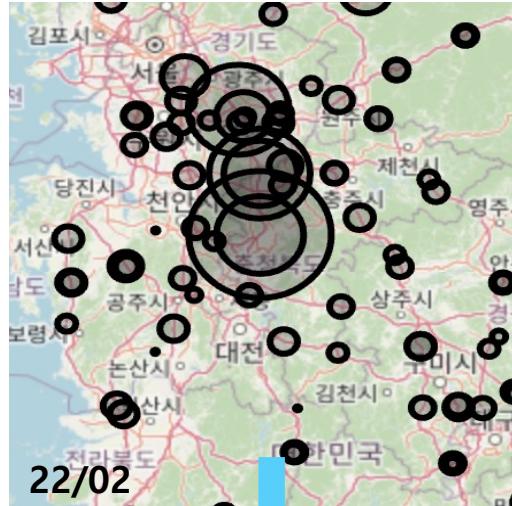
To support this, the average traffic volume and length of each cone zone were set to the X and Y axes, respectively, and the result of expressing it as a Scatter Plot showed a similar relationship between the average traffic volume and length.

Visualize and analyze data - Correlation between Traffic and Charging

Traffic in Southeastern Gyeonggi Province



Charge in Southeastern Gyeonggi Province



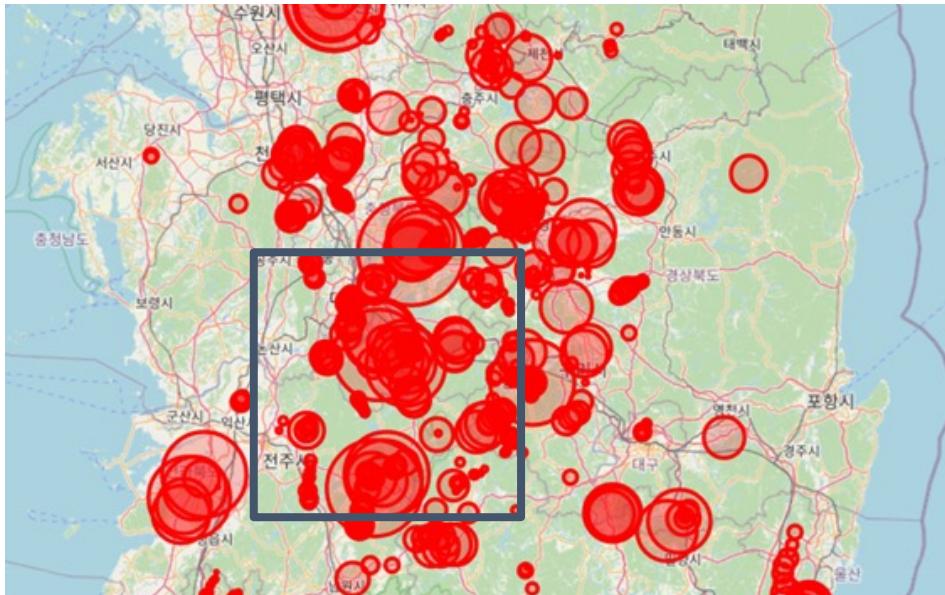
As the traffic volume increases, the average amount of charging increases, and the number of chargers overall increases in proportion

	2021	2022	Increase/Decrease
Number of Chargers	536	765	+229
Average Charge (kW)	23.50	27.95	+4.45

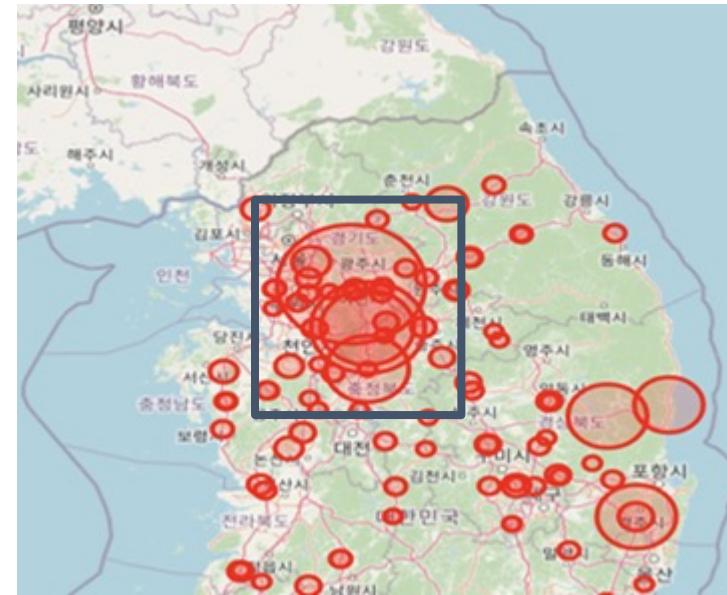
Check the proportional relationship between traffic volume and charging volume

Visualize and Analyze Data - The Relationship Between Traffic and Charging Volume: Focusing on the Central Region

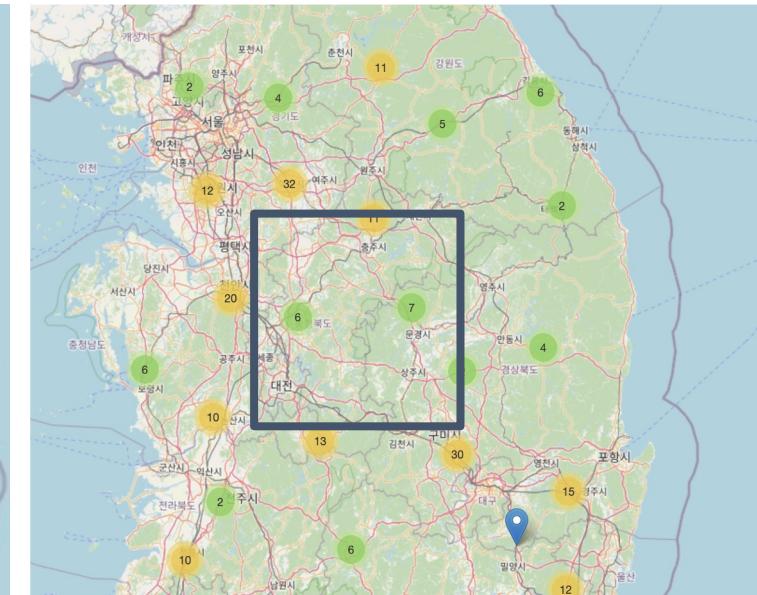
Traffic



Charge at EV charging station



Arrangement of electric vehicle charging stations in highway rest areas



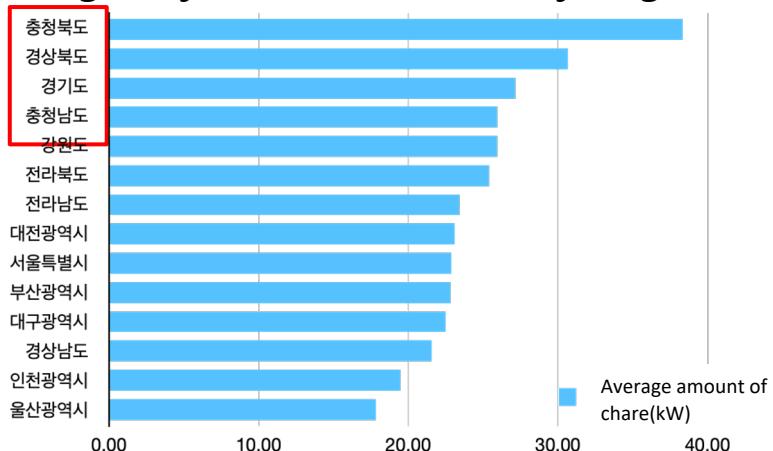
The central region was collectively referred to as 'Gyeonggi Nambu, Chungcheongbuk-do, Gyeongsangbuk-do, and Chungcheongnam-do'

The map above confirmed the high traffic volume and the charging volume of many electric vehicle charging stations. In comparison, it was possible to check the number of electric vehicle charging stations in highway rest areas.

In addition, the chart on the right shows the average charge of highway service areas by region. Able to check 'Chungcheongbuk-do, Gyeongsangbuk-do, Gyeonggi-do, Chungcheongnam-do'. Based on the number of electric vehicle charging stations in the rest area, which is still small compared to the high charging capacity,

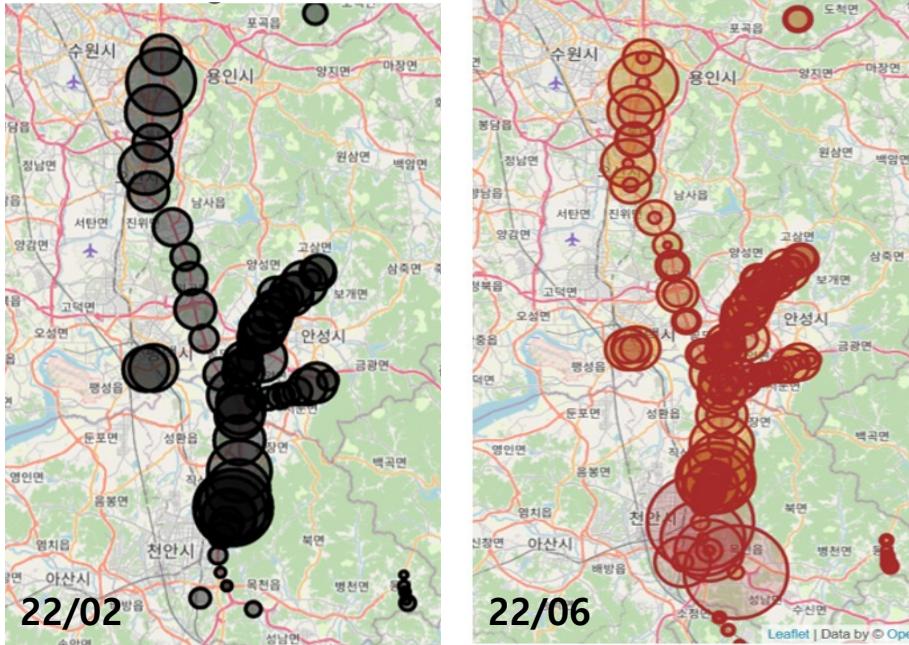
The central region can be considered as a priority for supplying chargers.

Average Charge Ranking for Highway Service Stations by Region



Visualize and Analyze Data - The Relationship Between Traffic and Charging Volume: Focusing on the Central Region

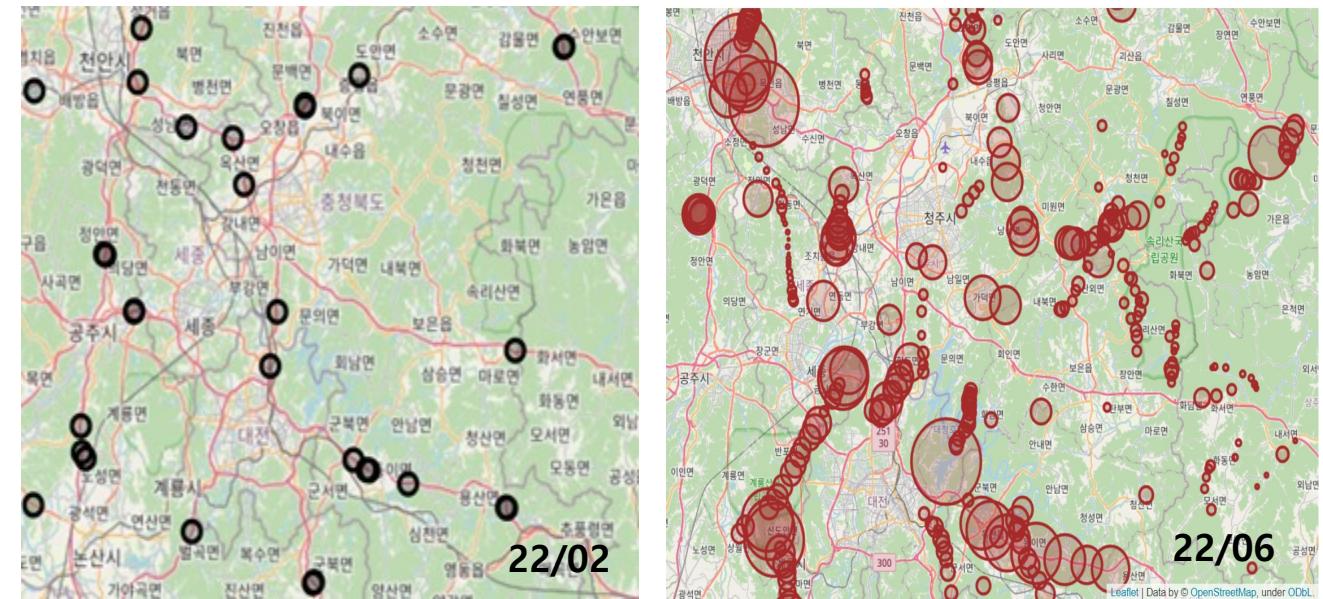
Changes in traffic volume to Suwon – Cheonan (Southern Gyeonggi)



According to the comparison between February and June 2022, there is no significant difference in overall traffic, **but it boasts high traffic volume every month.**

According to the correlation we've seen earlier, **High traffic means a high charge is required.**

Charger Arrangement and Traffic Volume in Chungbuk Highway Service Area

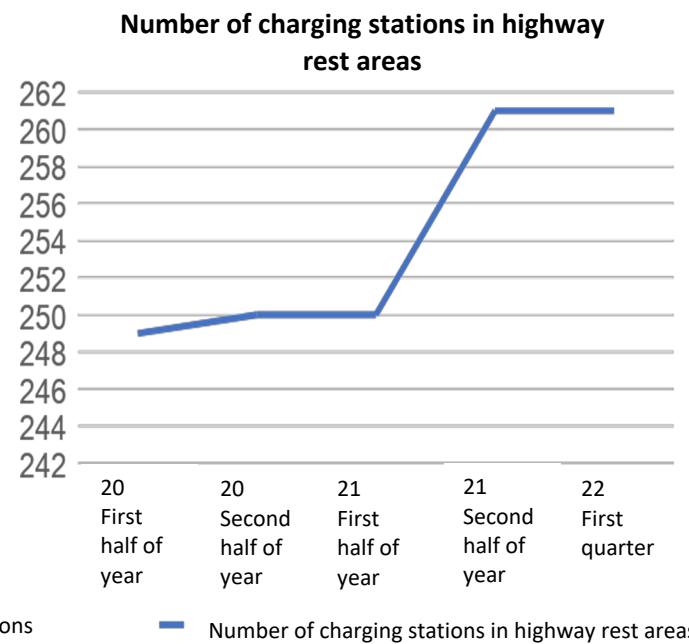
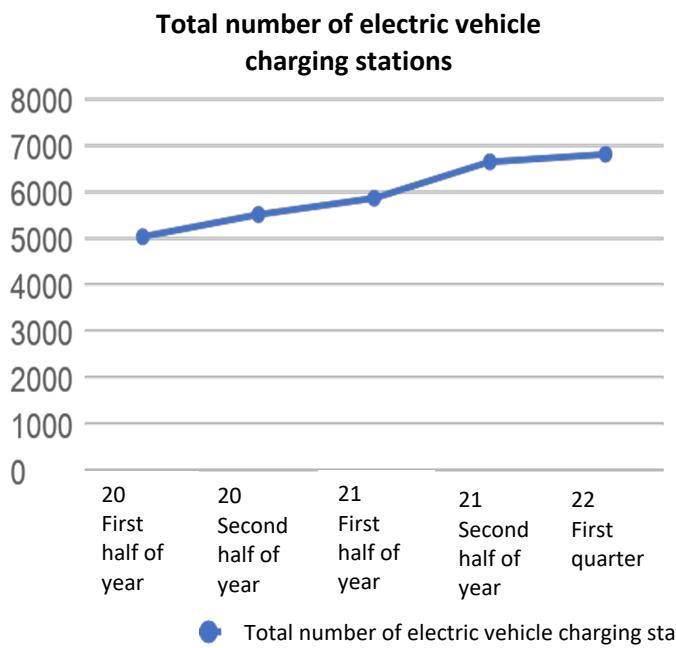


In 2022, the number of chargers in Chungbuk Expressway Service Area increased a lot, but the number of chargers is still insufficient compared to the average traffic volume in Cheonan and Daejeon areas

This area can be seen as a priority area where more chargers are needed!!!

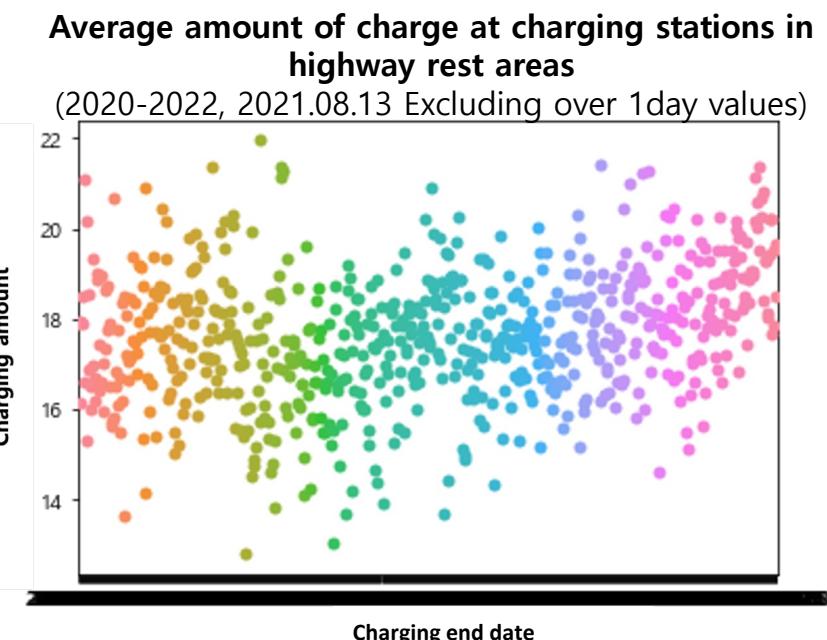
Visualize and Analyze Data

- Status of Charging Stations in Expressway Service Stations in Korea: Increasing Status and Average Charging Volume



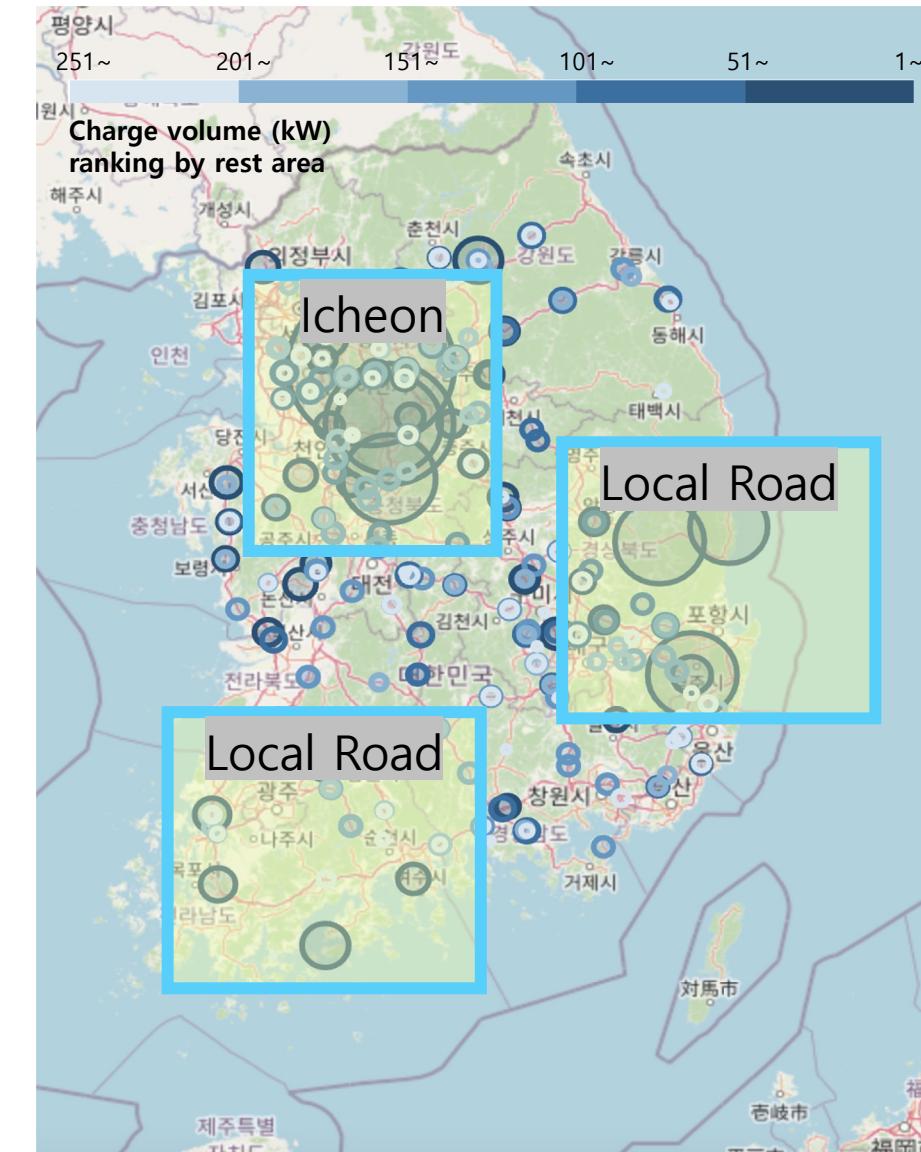
As the number of electric vehicle vehicles seen earlier increases, the number of electric vehicle charging stations nationwide is also increasing, and the number of charging stations in highway rest areas also increased from 249 charging stations in the first half of 2020 to 264 in the first quarter of 2022.

	2020 First half of year	2020 Second half of year	2021 First half of year	2021 Second half of year	2022 First quarter
Total number of the charging station	5033	5514	5867	6651	6814
Number of charging stations in highway rest areas	249	250	250	261	264



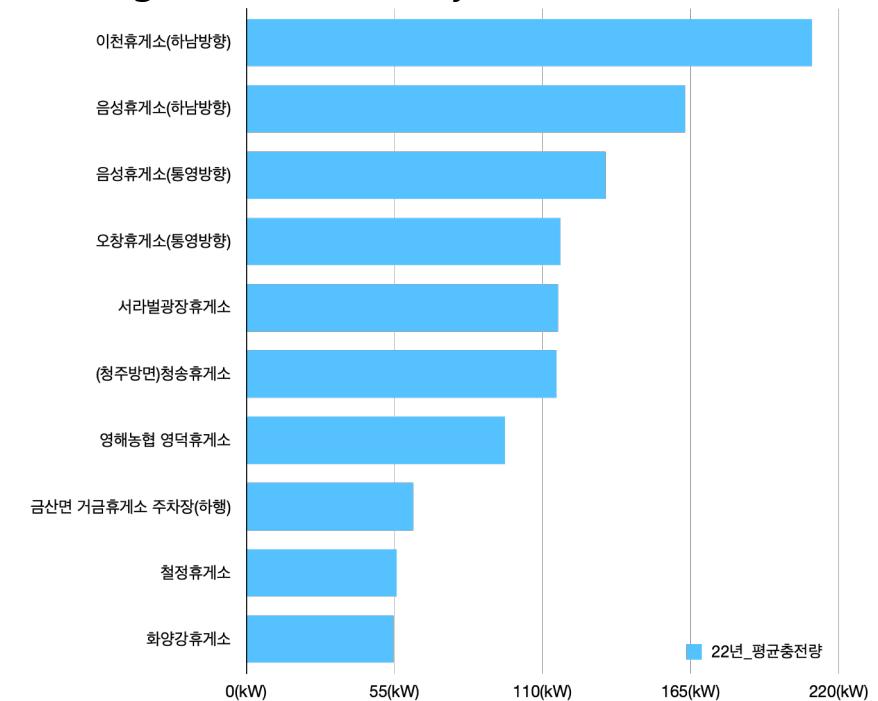
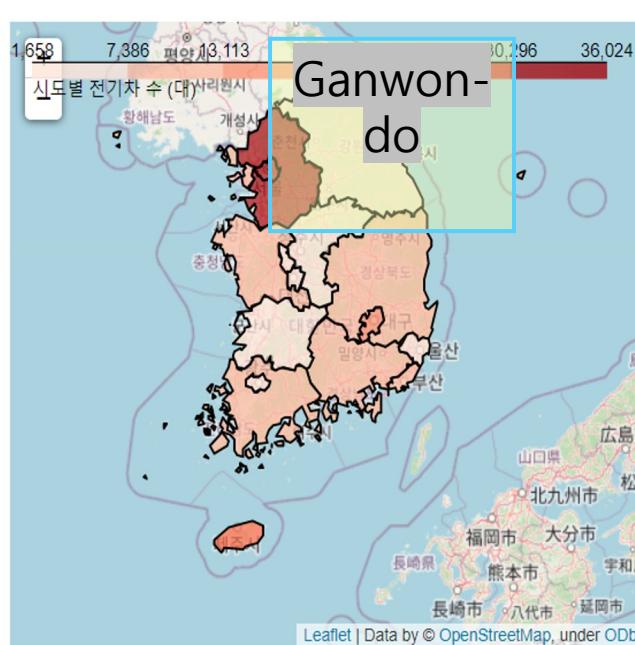
After looking at data for approximately two years and three months from 2020 to the first quarter of 2022, the overall charge at the charging station in the highway rest area is also on the rise, albeit small (August 13th, 2021 is a remarkably large anomaly.) Exclusively plot the graph) because it was visible)

Visualize and Analyze Data - The Status of Charging Stations in Expressway Service Stations in Korea



As a result of checking the top rechargeable rest area among rest areas,

- On average, the use of charging stations near Icheon, Gyeonggi Province, which mainly connects Seoul to the region, was high
- Charging stations at highway rest areas connecting the outer lines of each region are relatively high
- In Gangwon-do, where the supply of electric vehicles is relatively small, it was confirmed that the amount of charge was remarkably small.

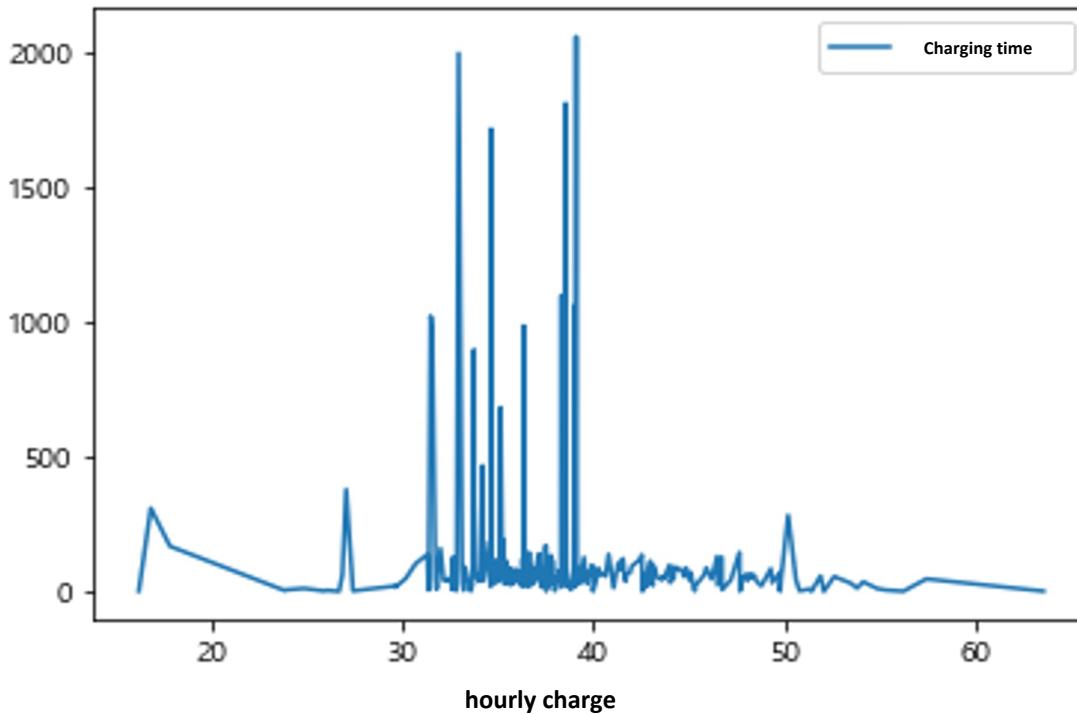


Visualize and Analyze Data

- Status of Charging Stations in Expressway Service Stations in Korea: Charging Speed and Distribution

	Slow charging		Fast charging	
	2~3kw output (Household Electricity)	7kw output (Speed Charger)	50kwh output	100kwh output
Charging time	Around 33 hours	Around 10 hours	Around more than 2.5 hours	Around more than 1.3 hours

* Actual charging time based on 64kwh battery (Kona, Niro, Volt EV)



- The actual speed of the fast charger is set to 50kwh, but overall, the average amount of charge per hour is distributed between 30 and 40kwh
- Need to improve the speed of existing devices as the total charging time exceeds 100 hours but there are still charging stations with low hourly charging (= slow charging)
- Since there is a time limit for charging up to 40 minutes on the highway, many people need to improve their speed even if they want to charge a lot in a short time.

Rest Area in Highway only has fast chargers

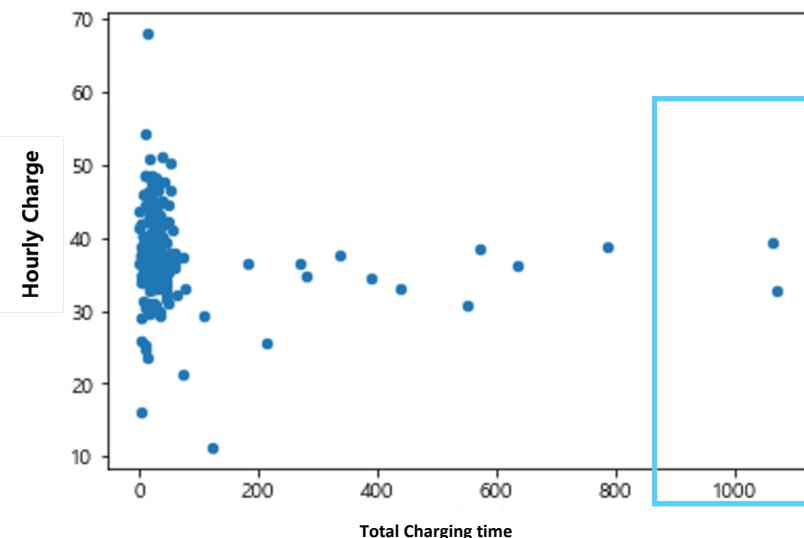
Visualize and Analyze Data

- Status of Charging Stations in Expressway Service Stations in Korea: Charging Speed and Distribution

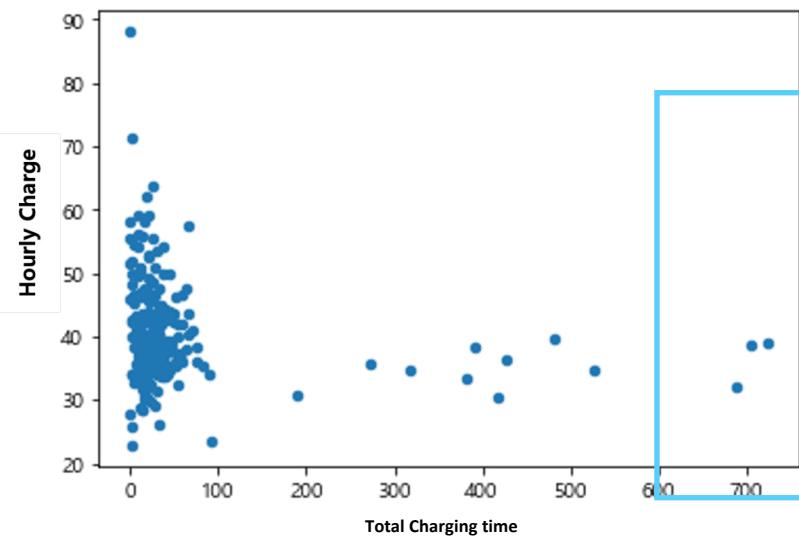
The data on the hourly rate of charge compared to the previous total charge time were divided by year and marked as a scatter plot

- Smaller but slightly higher hourly charge
- Total charging time and usage at certain charging stations alleviated the concentration of top charging stations
- 2 places were over 1000 hours in 2020, but only 1 place was over 500 hours in 2022
- The chart on the right shows 13 charging stations were charged more than 200 times in 2020, but decreased to 13 more than 100 times from 2021.

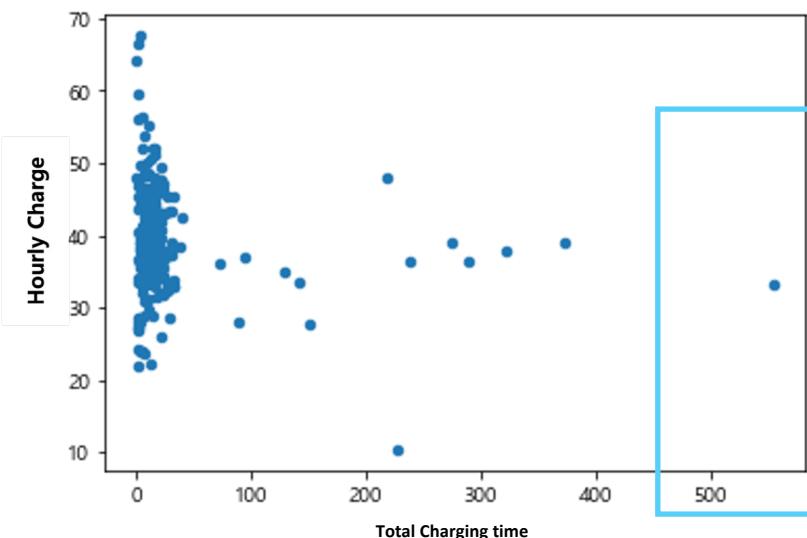
Period	Top used charging stations, (%)
2020 First half of year	13 locations over 200 times (47%)
2020 Second half of year	13 locations over 200 times (50%)
2021 First half of year	13 locations over 100 times (50%)
2021 Second half of year	14 places over 100 times (36%)
2022 First quarter	14 locations more than 100 times (46%)



2020



2021

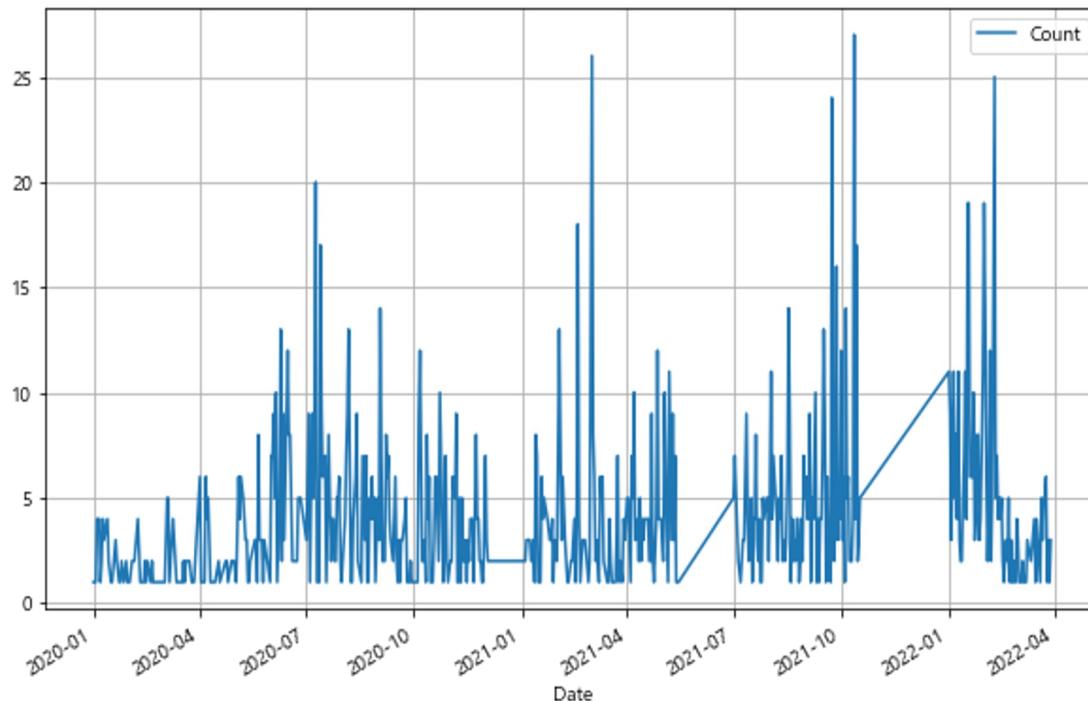


2022

Visualize and Analyze Data - Charging error data

Data showing abnormal charging type that cancels charging within 3 minutes are classified separately as charging error data.

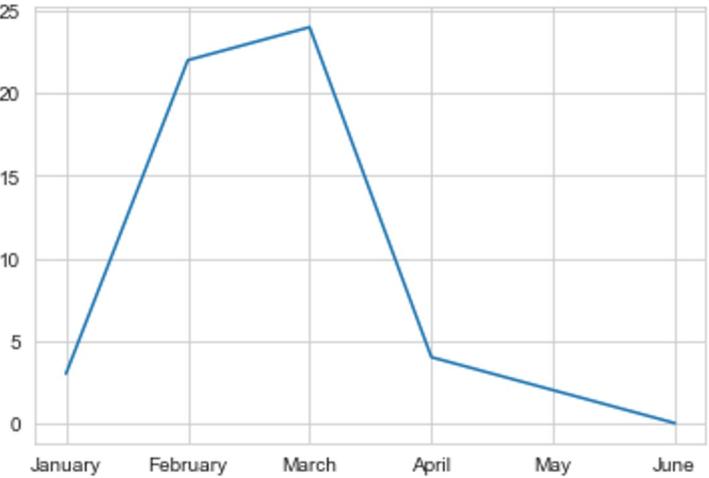
- divide this data by period and count the number of times,
- Visualization proceeds by dividing into all sections into time series data.
- A total of three devices were found that were believed to have failed.



Period	Charging error occurred (3 minutes or less)	Broken charger (estimated)
2020 First half of year	Total of 317, top 7, devices 55(13%): even distribution	X
2020 Second half of year	557 times in total Top 10 devices 115 cases (20%): even distribution	X
2021 First half of year	414 times in total 55 cases of No. 1 devices (13.28%): Suspected failure	7 (Euemsung rest area in Tongyeong) - Focus on a specific date.
2020 Second half of year	515 times in total Top 55 devices (10.67%): Suspected failure	8695 (Gyeongju IC Rest Area) – Continuous error occurrence (Nov and Dec data X)
2022 First quarter	415 times in total 177 cases (42.65%) of No.1 and No.2 devices: Suspected failure	8695 (Gyeongju IC Rest Area) – Estimated repair at the end of February 6055 (Yeonghae Agricultural Cooperative Yeongdeok Rest Area) – Estimated repair at the end of Feb

Visualize and Analyze Data

- Broken Estimation Charger Analysis from Charging Error Data: ID#7 for the first half of 2021 (Voice Service Area, Tongyeong)



After checking the detailed data,
The 3rd episode on February 18, 2021

On March 2, 2021, we found the history of intensively charging the same device twice within 5 minutes.

Points where errors are not consistently occurring and are concentrated on a specific date

Attempted to continue charging intensively at a specific times

→ Accordingly, it is estimated that **the driver is inexperienced or temporary UIX error, not device failure.**

However, since there were many errors of this device in the second half of the year, it is predicted that it may be a UIX environment other than the existing familiar UIX

The graph was drawn by counting the number of errors per month
It can be confirmed that errors occurred intensively in February and March 2021.

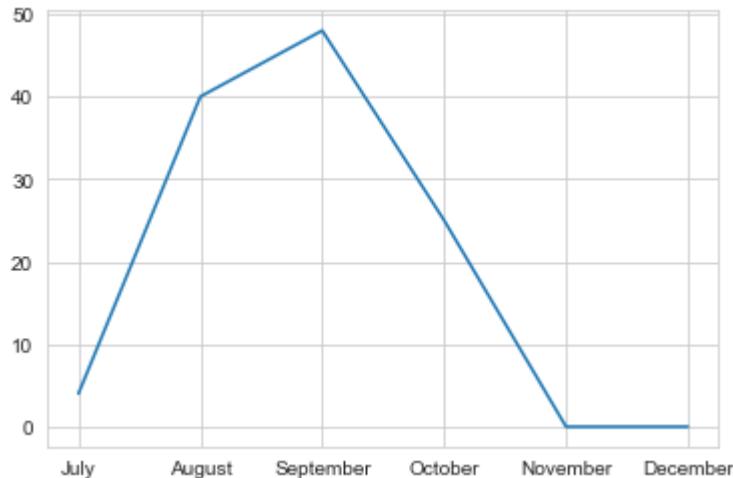
부분	사업소	충전 소명	충전기	충전기ID	주소	충전기구분	충전总量	충전량	충전시간	충전분	충전종료일자	충전시작시간	충전종료시간
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.14	0	0	2021-01-15	2021-01-15 4:01	2021-01-15 4:02			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.88	0	1	2021-01-19	2021-01-19 18:57	2021-01-19 18:59			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.04	0	0	2021-01-26	2021-01-26 10:04	2021-01-26 10:04			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	1.14	0	2	2021-02-17	2021-02-17 15:29	2021-02-17 15:31			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.22	~	~	2021-02-18	2021-02-18 13:07	2021-02-18 13:07			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.46	~	~	2021-02-18	2021-02-18 13:08	2021-02-18 13:09			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.08	~	~	2021-02-18	2021-02-18 13:10	2021-02-18 13:11			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.35	~	~	2021-02-18	2021-02-18 13:12	2021-02-18 13:13			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.87	0	1	2021-02-18	2021-02-18 16:04	2021-02-18 16:06			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.33	0	0	2021-02-18	2021-02-18 16:07	2021-02-18 16:08			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.21	0	0	2021-02-18	2021-02-18 16:11	2021-02-18 16:11			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.35	0	0	2021-02-18	2021-02-18 16:12	2021-02-18 16:13			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.13	0	0	2021-02-18	2021-02-18 16:14	2021-02-18 16:14			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.05	0	0	2021-02-18	2021-02-18 16:15	2021-02-18 16:15			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.05	0	0	2021-02-18	2021-02-18 16:16	2021-02-18 16:17			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.06	0	0	2021-02-18	2021-02-18 16:18	2021-02-18 16:18			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.03	0	0	2021-02-18	2021-02-18 16:20	2021-02-18 16:21			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.12	0	0	2021-02-18	2021-02-18 16:25	2021-02-18 16:25			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.11	0	0	2021-02-18	2021-02-18 16:30	2021-02-18 16:30			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-02-18	2021-02-18 16:42	2021-02-18 16:44			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-02-18	2021-02-18 16:44	2021-02-18 16:45			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-02-19	2021-02-19 20:41	2021-02-19 20:42			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-02-19	2021-02-19 20:44	2021-02-19 20:44			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-02-20	2021-02-20 14:33	2021-02-20 14:35			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-02-24	2021-02-24 20:56	2021-02-24 20:58			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:01	2021-03-02 12:02			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:03	2021-03-02 12:05			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:11	2021-03-02 12:11			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:16	2021-03-02 12:16			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:26	2021-03-02 12:26			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:28	2021-03-02 12:28			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:30	2021-03-02 12:31			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:37	2021-03-02 12:38			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:40	2021-03-02 12:41			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:43	2021-03-02 12:44			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:48	2021-03-02 12:48			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:51	2021-03-02 12:52			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:53	2021-03-02 12:54			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 12:59	2021-03-02 12:59			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:01	2021-03-02 13:02			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:06	2021-03-02 13:07			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:14	2021-03-02 13:15			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:17	2021-03-02 13:17			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:19	2021-03-02 13:19			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:21	2021-03-02 13:21			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:23	2021-03-02 13:23			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-02	2021-03-02 13:28	2021-03-02 13:28			
충북	음성	음성휴게소(급속01)	7 충청북도 음성군 급속	50	0.01	0	0	2021-03-08	2021-03-08 9:50	2021-03-08 9:53			

One bundle tied with a black border is estimated to be the same driver
(The charging attempt period is very short within 3 to 5 minutes)

2021/03/02

Visualize and Analyze Data

- Broken estimation charger analysis from charging error data: ID#8695 (Gyeongju IC Rest Area) in the second half of 2021



As a result of checking the detailed data, the error occurred evenly from August to October 2021. There is no data since October 17, 2021, but it is estimated that errors have occurred steadily. (Linked to data from Q1 2022)



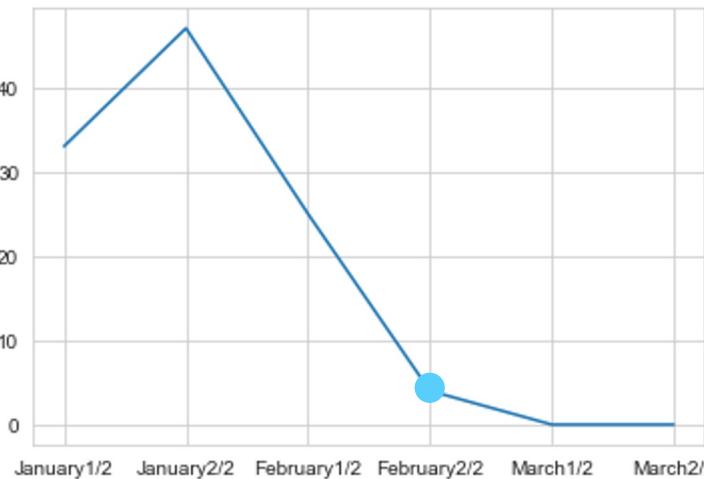
The graph was drawn by counting the number of errors per month
Problems continuously occurred from August 2021
(data from Korea Electric Power Corporation has been omitted since October 17, 2021)

대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.83	0	1	2021-07-13	2021-07-13 9:24
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	1	2021-07-18	2021-07-18 19:53
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	2	2021-07-30	2021-07-30 15:03
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.88	0	2	2021-08-01	2021-08-01 19:05
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	2	2021-08-01	2021-08-01 13:08
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.61	0	1	2021-08-02	2021-08-02 19:05
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-04	2021-08-04 14:05
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.05	0	0	2021-08-04	2021-08-04 18:46
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.02	0	0	2021-08-04	2021-08-04 14:00
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-05	2021-08-05 19:02
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-06	2021-08-06 11:44
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.02	0	0	2021-08-06	2021-08-06 12:55
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.02	0	0	2021-08-08	2021-08-08 10:21
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-10	2021-08-10 13:10
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-14	2021-08-14 9:34
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	2	2021-08-15	2021-08-15 17:23
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.03	0	0	2021-08-15	2021-08-15 16:51
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.02	0	0	2021-08-16	2021-08-16 19:07
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-16	2021-08-16 17:01
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.05	0	0	2021-08-16	2021-08-16 16:13
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.02	0	0	2021-08-16	2021-08-16 16:14
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-17	2021-08-17 18:32
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.05	0	0	2021-08-17	2021-08-17 18:53
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.05	0	0	2021-08-17	2021-08-17 18:35
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-17	2021-08-17 19:00
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-17	2021-08-17 8:24
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-17	2021-08-17 8:30
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-17	2021-08-17 18:30
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.02	0	0	2021-08-18	2021-08-18 18:25
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.03	0	0	2021-08-18	2021-08-18 20:06
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.06	0	0	2021-08-18	2021-08-18 18:32
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.04	0	0	2021-08-18	2021-08-18 20:10
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.04	0	0	2021-08-18	2021-08-18 20:08
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.06	0	0	2021-08-22	2021-08-22 12:26
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-22	2021-08-22 13:54
대구	경주	경주IC휴게 : 급속01	8695	경상북도 경급속	50	0.01	0	0	2021-08-25	2021-08-25 11:11

Black border on a daily basis,
which identifies consistent errors over multiple days

Visualize and Analyze Data

- Fault Estimation Charger Analysis from Charging Error Data: Q1 2022 ID#8695, ID#6055

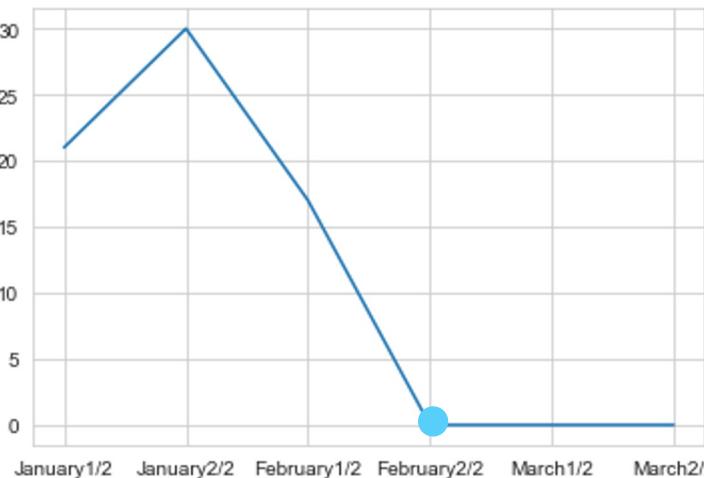


Estimated Fault Charger Analysis - Q1 2022 ID#8695 (Racing IC Rest Area)

The graph was drawn by counting the number of errors every 15 days
The problem has dropped sharply since late February 2022. It can be inferred that the repair has been completed at this point, as there is no such thing as after March.

It is presumed that the problem that began to occur in August 2021 was solved in February 2022.

It took about 6-7 months to identify and resolve the problem, but it seems that faster action is needed



Estimated Fault Charger Analysis - Q1 2022 ID#6055 (Yeongdeok Rest Area)

The graph was drawn by counting the number of errors every 15 days
Since there is no error from late February 2022, it can be inferred that the repair has been completed at this time.

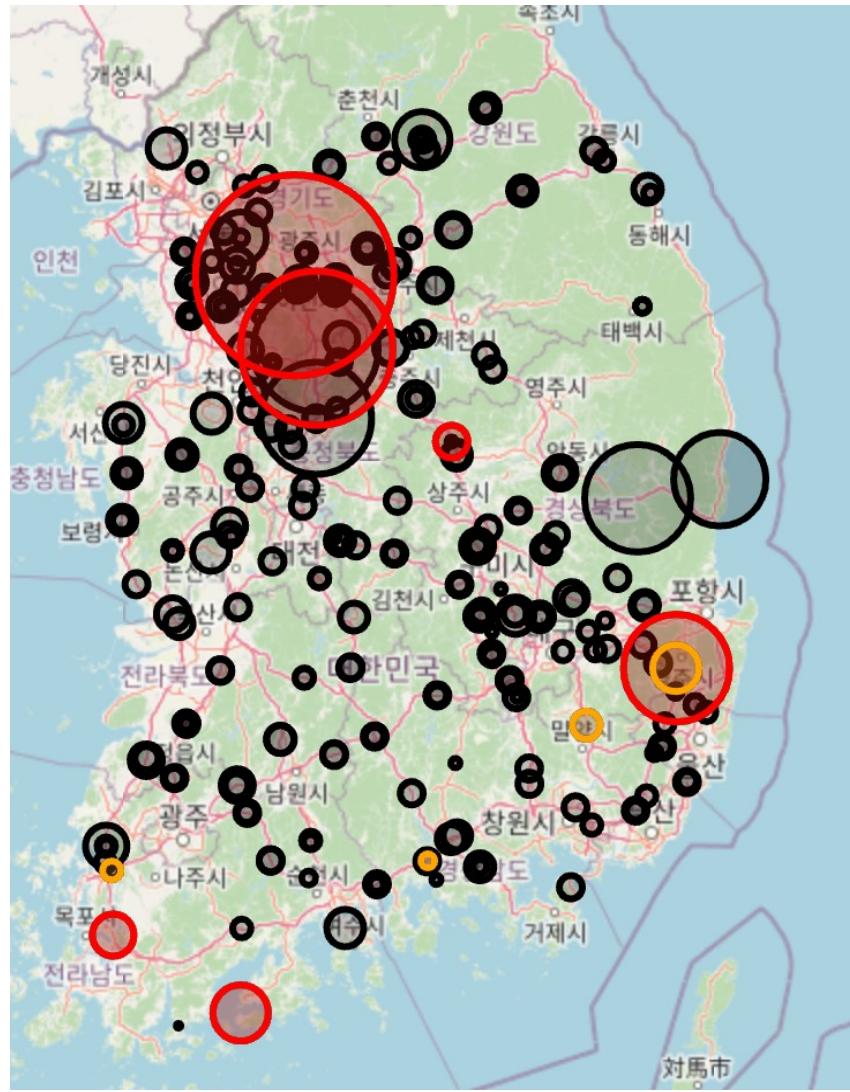
Resolve problems that have occurred since the beginning of January relatively quickly, as opposed to the above cases.

► Continuous monitoring and management of already installed charger devices is also required.

Conclusion

- Expectation Effectiveness
- Limit Point
- Suggestion future improvement directions

Visualize and Analyze Data



■ Charger supply priority selection

Name of Rest Area	Charger Increase/decrease rate (%)	Charging amount Increase/decrease rate (%)
Icheon Rest Area (Hannam direction)	100.0	94.69
Voice rest area (Hannam direction)	100.0	103.73
Seorabeol Square Rest Area	100.0	73.3
Muan Cheongho Rest Area	0.0	99.38
Maseong Sleepy Rest Area Upward	0.0	95.28

■ Ranking after supplying the charger

Name of Rest Area	Charger Increase/decrease rate (%)	Charging amount Increase/decrease rate (%)
Ochang Rest Area (Tongyeong direction)	100.0	-23.93
Gyeongju IC Rest Area	100.0	-14.19
Going down to Cheongdo Saemaeul Rest Area (Busan)	100.0	-15.82
Hampyeong Butterfly Rest Area (Muan direction)	100.0	-33.81
Anseong rest area (Pyeongtaek direction)	100.0	-25.4

- We selected rest areas where the number of chargers is the same compared to 21 years, but the amount of charging has increased significantly.
- Although the number of chargers increased compared to the 21s, the amount of charging increased a lot, so future charging stations were also considered.
- In the future, if chargers are supplied to the rest area first, we have selected places that are likely to be more utilized than other rest areas.
- Chargers were more than twice as popular as in 21 years, but rather, charging stations with reduced charging volume were selected.
- I chose the rest stop because I thought it would be okay to postpone the order of supplying the charger.

Analyze to derive insights

Expectation Effectiveness

1. When planning to supply chargers with a limited budget, one charger can charge more by finding the priority of areas where more chargers are needed, thereby improving the availability rate of chargers.
2. If the data is recorded in an abnormal pattern defined by the charger, the failure code is generated and the maintenance priority of the department maintaining the charger is placed, and the charger that is not reported can be maintained without being left unattended for a long time.

Limit point

1. With the currently collected data, it was not possible to clearly confirm what should be prioritized in the supply and maintenance of chargers to help improve inconvenience for electric vehicle users.
2. It was difficult to separate whether the frequent errors of the charger were exactly the device's failure or the user's inexperience.

Suggestion future improvement directions

Briefly organize the results from above

- Most of the fast-charging stations are concentrated in the rest area, so it would be better to focus on places with a lot of people rather than the rest area
- Since the central part of the country has a lot of traffic and charging, I hope that additional chargers will be considered first

Suggestion future improvement directions

- 1. We drew conclusions on the supply priority of chargers by simply looking at changes in traffic volume, changes in charging volume, and changes in the number of chargers in the area, but we want to combine more diverse data to create more effective priorities.
- 2. We would like to learn charger usage patterns directly by the machine to separate the failure from the inexperience of use and to respond more effectively to the failure.
- 3. Considering data on the government's budget and budgeting method for supply and maintenance, we would like to set a direction so that infrastructure that can be followed in line with the expansion of electric vehicle supply can be established in the right place.

At the end of the project,

- Review of development
- References

Review of development



Min-ji: For the first time, it was a great experience to deal with over 1 million lines of data. I was able to exchange opinions with my teammates and work happily because they were in sync.



Si-chan: It was a great experience to feel cooperation with team members by preprocessing, analyzing, and deriving results from public data. I gained confidence in data-related work. I wanted to develop more and analyze it professionally. :)



Ju-yeon: It was a great experience to preprocess vast amounts of data, modeling, visualization, and even elicit opinions. In addition, it was the first time that location-based data was dealt with in earnest, and it was an opportunity to know the characteristics of location data. I think it will be a good memory because the teamwork with the team members was good too :)



Do-eun: I think it was more beneficial to be able to do data-based projects directly, not just taking lectures. It was a great motivation that all the members of the group were passionately in charge of their duties.



Byung-woo: I was so grateful for the programming that I could work on such a large amount of data smoothly, and it was an opportunity to realize once again that it was really different from when I learned it myself, and I was so grateful for the opportunity to gain this experience.

Sources of Reference

(Photo source)

Photograph of Charger Production Line: Tesla Gigafactory

Charging station waiting line 1: Yonhap News

<https://www.kado.net/news/articleView.html?idxno=1064945>

Charging station waiting line 2: businesskorea

<http://www.businesskorea.co.kr/news/articleView.html?idxno=43896>

Charging station failure (yellow line): GD Net Korea <https://zdnet.co.kr/view/?no=20190929131531>

Charging station failure (discontinuation of charging operation): Jeminllbo

<http://www.jemin.com/news/articleViewAmp.html?idxno=724639>

Electric vehicle charging time:

<https://www.evpost.co.kr/wp/%EC%A0%84%EA%B8%B0%EC%B0%A8-%EC%B6%A9%EC%A0%84%EC%8B%9C%EA%B0%84-%EC%A0%95%EB%A6%AC-%EC%9D%B8%EA%B8%B0%EA%B8%80/>

(Source of comments)

Electric Vehicle Club Cafe:<https://cafe.naver.com/allfm01>