Electric Vehicle Charging Stations

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Methodological Approach

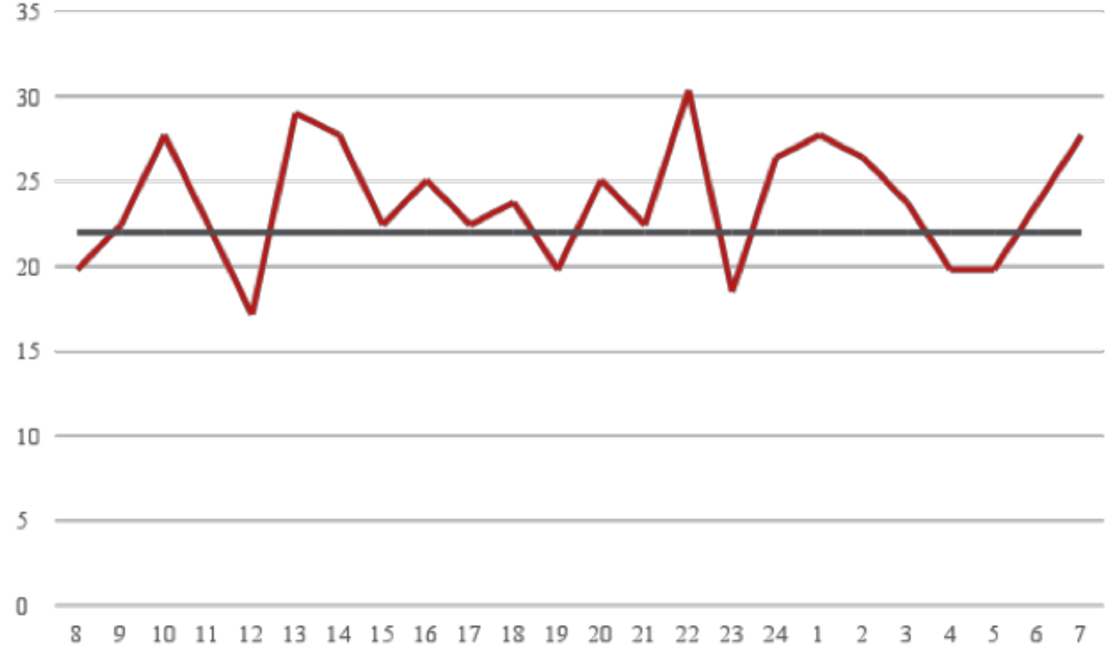
The process of planning EVSE (Electric Vehicle Support Equipment) infrastructure is approached from 3 aspects:

1. Site Selection

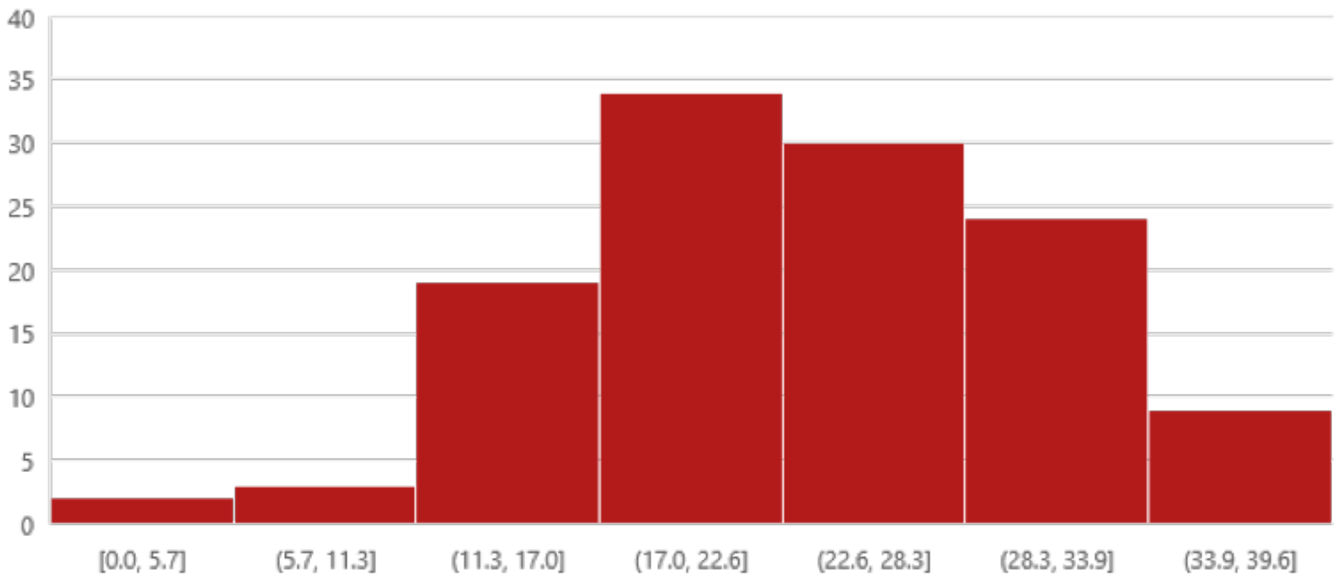
- To make the decision support as simple as possible we will mainly be considering the total load generated by planned and existing charging points to see if a particular location will exceed the maximum grid load at any point. If not the plan is a go. If it does we can either reduce the planned number of charging stations, increase the grid capacity or evaluate a different location.
- Range Anxiety SoC, which is defined as the state of charge below which the owner feels compelled to charge, is estimated using lognormal distribution.
- The state of charge of a vehicle parked in a charging space is simulated.
- If it is below the range anxiety SOC an additional load of 6.6 kW is assumed on the grid.
- If the total load applied by all the CS at a particular time exceeds the peak power supply, then further installations of CS on that site to increase power demand is not recommended

Site Selection

Load - Time Series



Frequency Plot - Cumulative EV Load



2. Capacity Management

The main objective is to estimate the increase in grid demand due to Electric Vehicles.

- Factors- EV penetration, spatial distribution of charging stations, time in the day of vehicle charging, charging rate, energy consumed per charge

- SOC estimation- Depends on distance travelled by the car, estimated assuming a lognormal distribution with mean distance travelled- 22 miles and standard dev- 12 miles. Range- 100 miles and charged once in three days.

- Time of day distribution- Assumed to be a normal distribution with mean at 12pm and standard deviation of 4 hours.

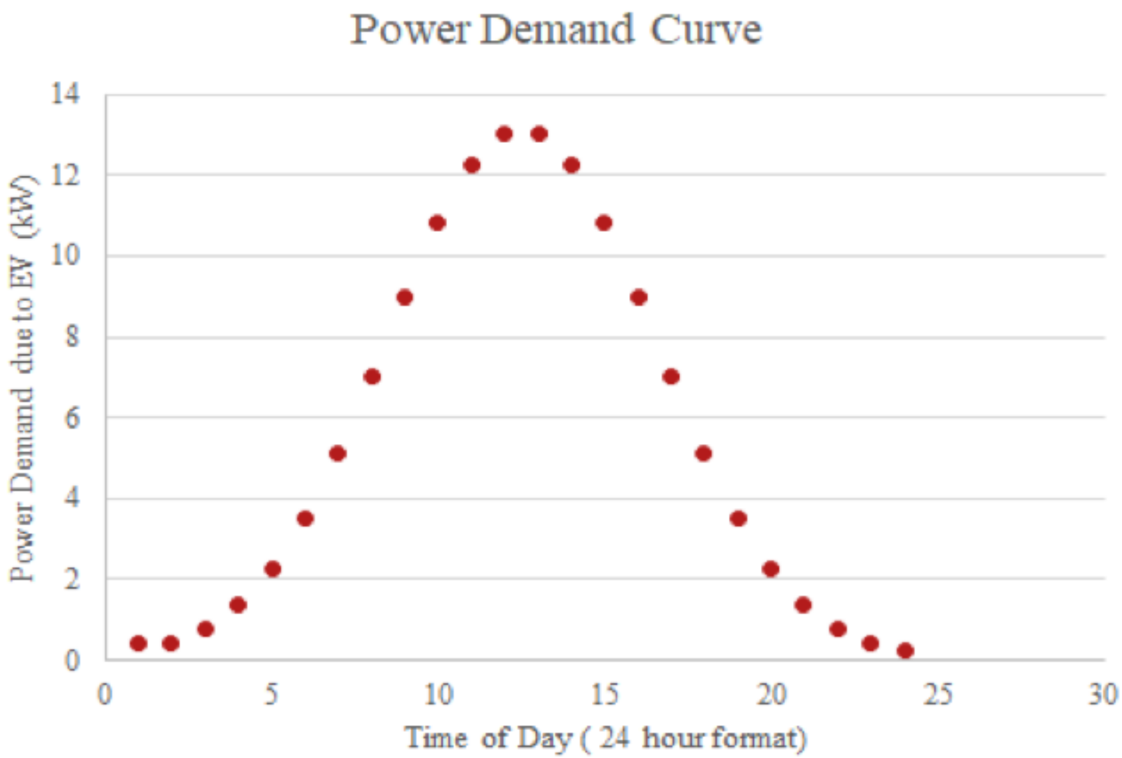
- Charging rate- 6.6 kW and 20 charge points.

$$E_i = \left(1 - \frac{\alpha d}{d_R}\right) \times 100\% \qquad P_n = \sum_{i=1}^{n} \sum_{j=1}^{n_c} P_j \cdot \Phi(P_j, t)$$

The adequacy of the grid to match the power demand curve needs to be ascertained from the Power vendor.

Data needed:

- Time of day of charging
- State of charge at the time of charging
- Spatial distribution and number of charging stations and charge points.



3. Cost Recovery

Total electricity use

$$f_c^{ELEC}(\beta,\gamma,L) = \sum_{a=1}^{L} f_{ca}^{ELEC}(\beta,\gamma)$$

Total gasoline use

$$f_c^{GAS}(\beta,\gamma,L) = \sum_{a=1}^{L} f_{ca}^{GAS}(\beta,\gamma)$$

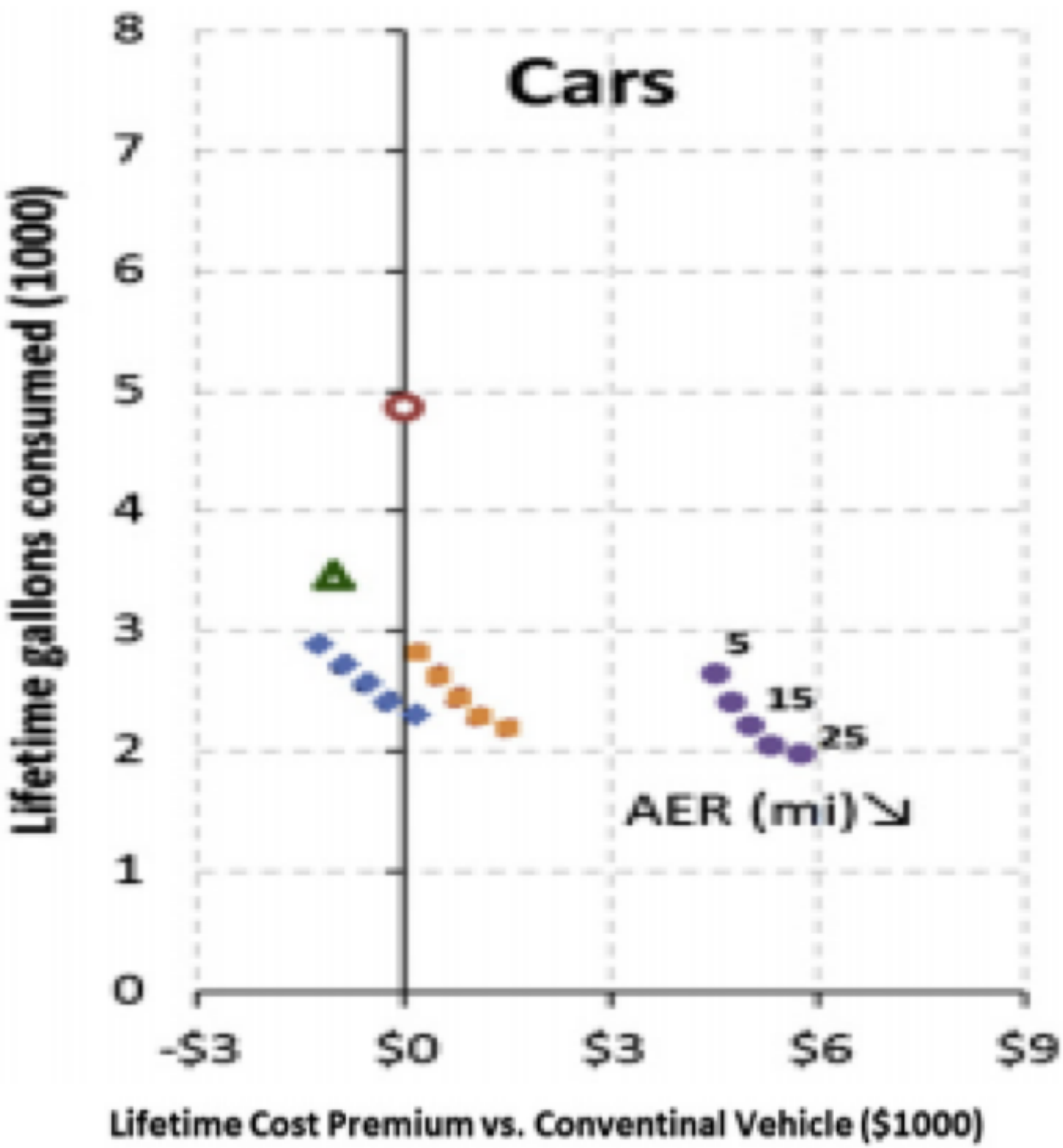
$$f_{ca}^{ELEC}(\beta,\gamma) = 104 \frac{\sum_{j\in J_{a,c,WE}} d_j^{CD}(\beta,\gamma)}{|J_{a,c,WE}|\eta_c^{CD-E}} + 261 \frac{\sum_{j\in J_{a,c,WD}} d_j^{CD}(\beta,\gamma)}{|J_{a,c,WD}|\eta_c^{CD-E}}$$

$$f_{ca}^{GAS}(\beta,\gamma) = 104\left(\frac{\sum_{j\in J_{a,c,WE}} d_j^{CD}(\beta,\gamma)}{|J_{a,c,WE}|\eta_c^{CD-G}} + \frac{\sum_{j\in J_{a,c,WE}} d_j^{CS}(\beta,\gamma)}{|J_{a,c,WE}|\eta_c^{CS-G}}\right) + 261\left(\frac{\sum_{j\in J_{a,c,WD}} d_j^{CD}(\beta,\gamma)}{|J_{a,c,WD}|\eta_c^{CD-G}} + \frac{\sum_{j\in J_{a,c,WD}} d_j^{CS}(\beta,\gamma)}{|J_{a,c,WD}|\eta_c^{CS-G}}\right)$$

$$\text{Lifetime Cost Premium} = C_{PHEV,\,c}^{NPV} - C_{CV,\,c}^{NPV}$$

$$C_{PHEV,\,c}^{NPV} = D + \sum_{a=1}^{L} \frac{f_{PMT}(C_c - D, i, L) + p_a^{ELEC} f_{ca}^{ELEC}(\beta,\gamma) + p_a^{GAS} f_{ca}^{GAS}(\beta,\gamma)}{(1+r)^a} + C_{CH}$$

$$C_{CV,c}^{NPV} = \sum_{a=1}^{L} \left(\frac{\sum_{j\in J_{a,c}} d_j}{|J_{a,c}|\eta_c^{CV}}\right)\left(\frac{p_a^{GAS}}{(1+r)^a}\right)$$


Cars
Lifetime gallons consumed (1000)
8
7
6
5
4
3
2
1
0
-$3
$0
$3
$6
$9
5
15
25
AER (mi)↘
Lifetime Cost Premium vs. Conventinal Vehicle ($1000)

Recommendations

Based on assessment of the situation and requirements of Cornell Transportation, utilizing six-sigma tools, research in electric charging industry and simulated model results, please consider the follows should conditions apply :

- Collect data as per the list provided in the report. This will provide quantitative decision support if used in conjunction with the models provided in the report.
- Follow the procedure highlighted for each part of the infrastructure planning process as elucidated in the simulations.
- Use the excel workbook provided (with the model equations) to plug in the data as and when becomes available to run the model to ensure soundness of any proposal.

Thank You !