SYSEN 5300 Final Project: **Electrifying Cornell Fleet**

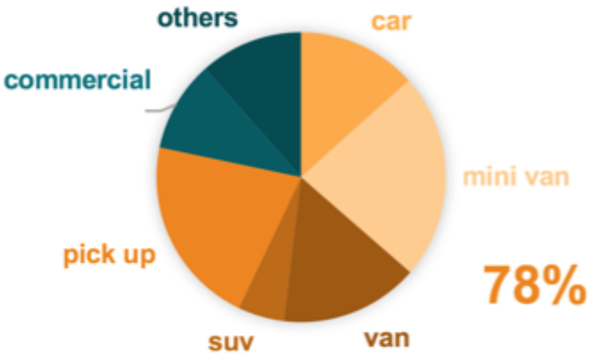
Nilesh Deshpande, Ye Lin Kim, JD Paff, Daniel Sachs

Cornell’s Goal: Carbon Neutral by 2035

How to get there…

- More Efficient Buildings
- **Electric Vehicles**
- Greener Energy Production

700 Fleet Vehicles



Project Objectives:

- Evaluate the cost effectiveness of transitioning Cornell’s fleet to EV
  - Identify potential obstacles/risks associated with adopting EV solution
  - Model fleet utilization in order to project future usage
  - Determine optimized EV solution
  - Propose next steps

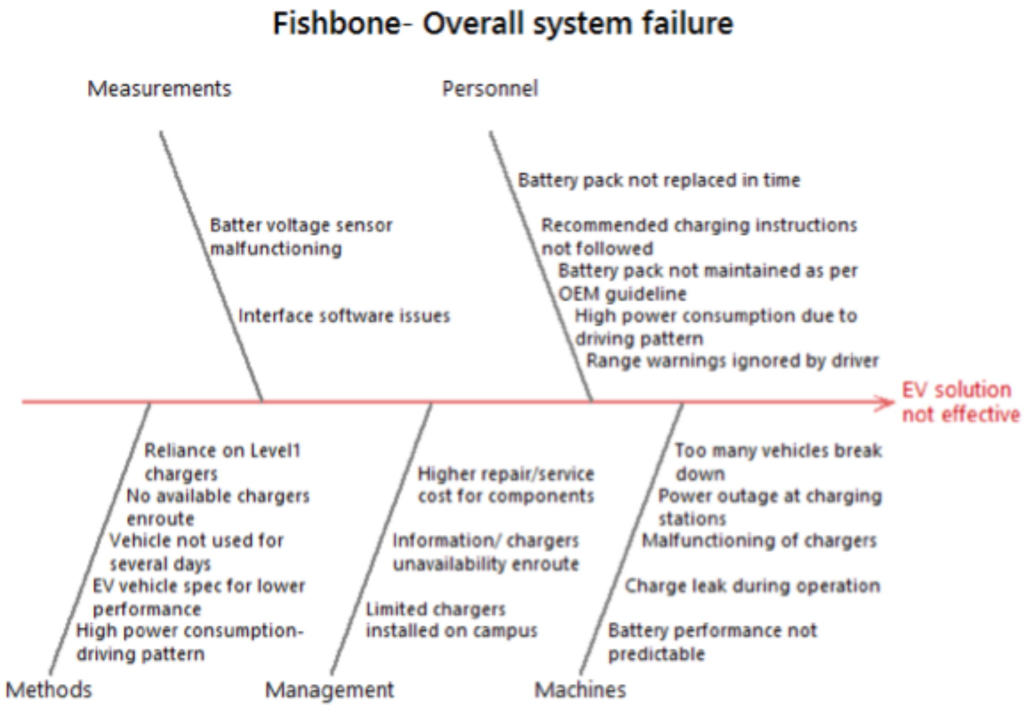
System FMEA Summary

- FMEA document created for top failure modes of the system (vehicle, charging infrastructure failure and overall system)
- Mitigation plan proposed for top 7 risk items
- Top 3 risks highlighted in table below with mitigation plan

Item / Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s) / Mechanism(s) of Failure	Occur	Current Design Controls	Detect	RPN	Recommended Action(s)	Responsibility & Target Completion Date
EV/PHEV-Vehicles	Electric range unpredictable	Range anxiety for driver	5	Recommended charging instructions not followed	2	- OEM recommended charging instructions	4	40	- Create SOP for users for charging practices	Cornell, Transport Dept Post solution recommendation
			5	High power drawn by motor due to driving pattern	3	- Vehicle warning signs showing non optimal use	4	60	- Monitor vehicle usage pattern on select vehicle during a pilot run before finalizing solution	Cornell, Transport Dept Post solution recommendation
	EV runs dry in remote location	User inconvenience	5	Range warnings ignored by driver	4	- Vehicle warning signs showing heavy power usage	4	80	- Ensure range warning signs are notice- able (hooters, blinkers) - Connect vehicles to central servers for remote gatering and monitor data	Cornell, Transport Dept Post solution recommendation

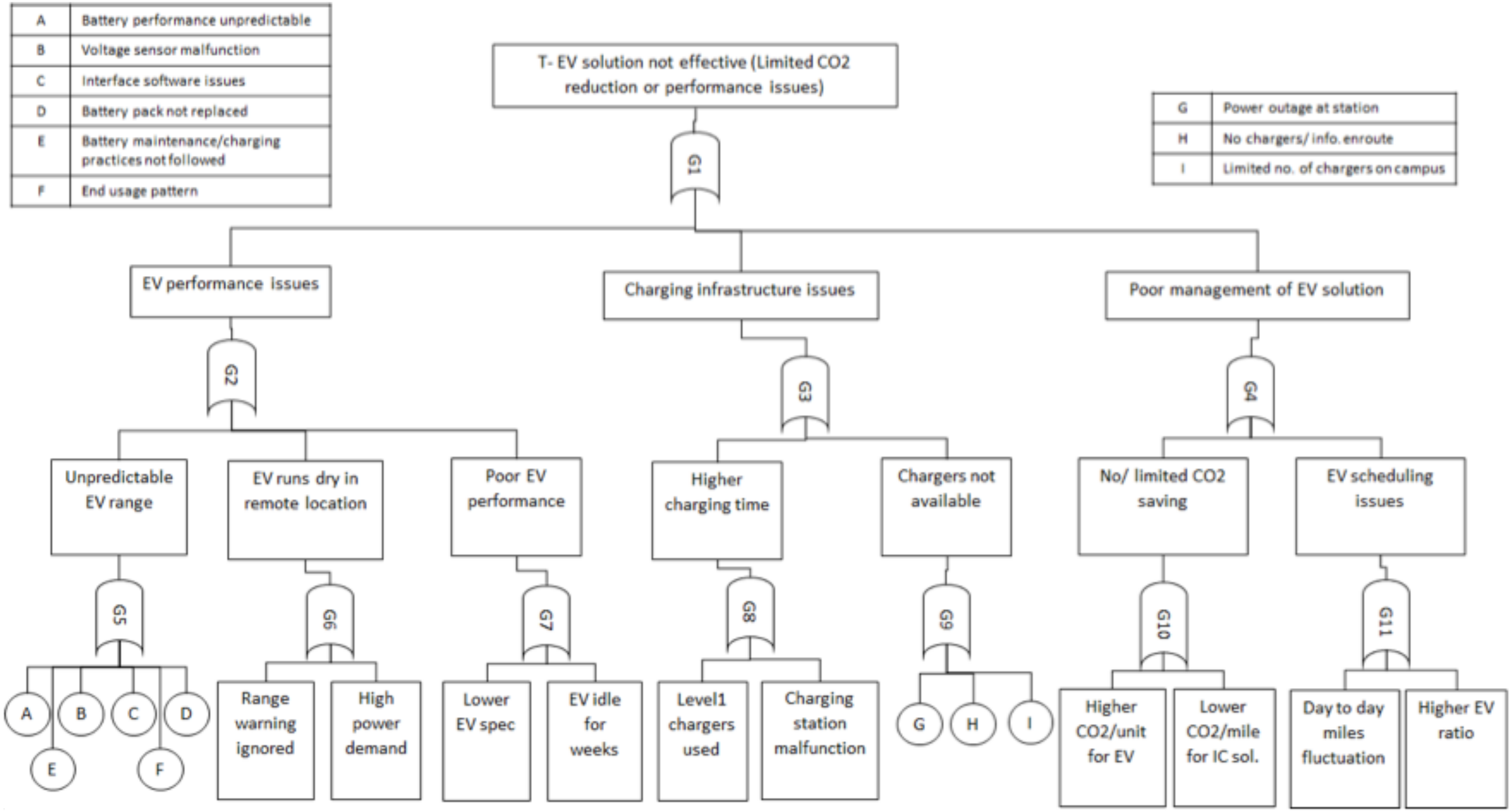
Fishbone Summary

- Fishbone diagram laid out for categorizing identified risks into various sources
- Top failure modes are linked to-
  - **Man**- usage pattern, maintenance practices, ignoring range warnings
  - **Machine**- vehicle/chargers breakdown, power cuts, interface software
  - **Method**- type of chargers used, EV vehicle selection, enroute chargers availability



Fault Tree

- FTA framework created to provide an estimate of overall system reliability
- Limited data on individual failure mode probabilities → Reference for future work when EV technology matures for accurate estimation of failure probabilities



Current EV Options



PHEV

Chevy Volt

Bolt

Toyota Prius Prime

Ford Fusion Energi

BEV

Chev

Tesla Model 3

Ford Focus



Scoring Criteria

- Availability
- Cost
- Electric Range
- MPG

(normalized to 5pt scale)

Minivan
Chrysler Pacifica
(PHEV)

SUV
Mitsubishi Outlander
(PHEV)

Pickup
Workhorse W-15
(PHEV)

Van (passenger or cargo)

Zenith Motors
(BEV)

Via Motors
(PHEV)




Data Provided + Method

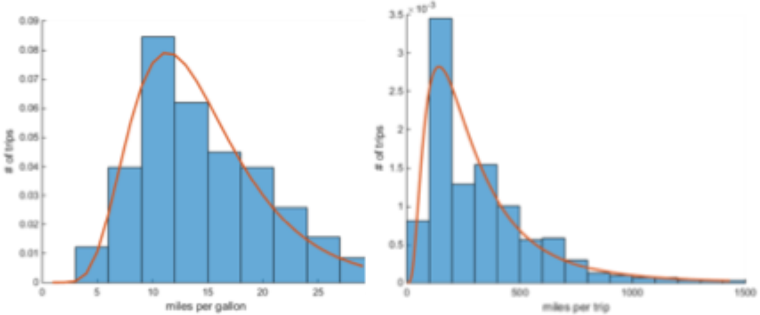
RAW DATA from CTECH and Cornell Transportation and Mail Services:

- **Fuelmaster transactions**: Transaction information classified by Vehicle ID
- **Asset Data**: Vehicle ID, Model, Make

Sort raw data into the different vehicle types to determine:
FLEET SIZE, **TRIPS PER YEAR**, **TRIP LENGTH (MPT), FUEL ECONOMY (MPG)**

Plot histograms of MPT and MPG
Fit best probability distribution, find parameters, average, and standard deviation:

HISTOGRAM AND DISTRIBUTION FOR CAR



Vehicle Type	Count	Trips per Year	Distribution					
			MPT	E, SD	Parameters	MPG	E, SD	Parameters
Car	80	1973	Lognormal	E: 323.53	Mu: 5.52	Lognormal	E: 14.5	Mu: 2.59
				SD: 240.25	Sigma: 0.75		SD: 5.7	Sigma: 0.41
Minivan	138	3235	Lognormal	E: 208.09	Mu: 5.03	Weibull	E: 10.14	A: 11.33
				SD: 201.06	Sigma: 0.76		SD: 3.55	B: 3.06
Van	93	1781	Lognormal	E: 165.63	Mu: 4.94	Normal	E: 7.79	Mu: 7.79
				SD: 103.52	Sigma: 0.67		SD: 3.35	Sigma: 3.35
SUV	31	1868	Lognormal	E: 93.42	Mu: 4.28	Lognormal	E: 7.13	Mu: 1.89
				SD: 96.85	Sigma: 0.68		SD: 2.76	Sigma: 0.38
Pickup	127	2736	Gamma	E: 218.39	a: 2.05	Gamma	E: 8.00	A: 3.53
				SD: 180.46	b: 106.51		SD: 4.33	B: 2.27

<u>Weibull</u>
a: scale parameter
b: shape parameter

<u>Gamma</u>
a: shape parameter
b: scale parameter

\+ **EV Options** (electric range, battery, MPG, Cost)

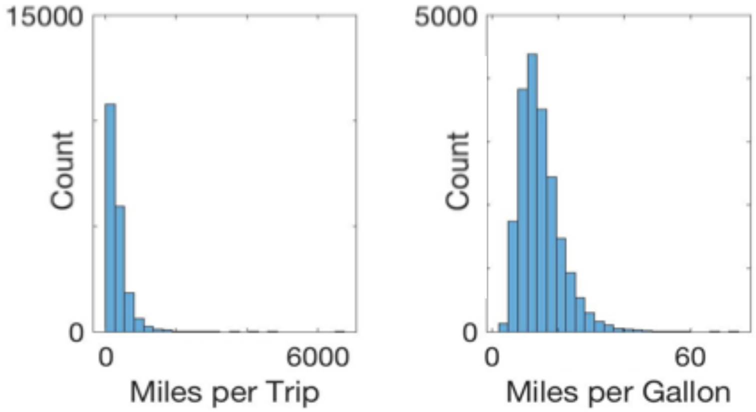
<u>MODEL INPUTS</u>

Model Algorithm

Goal - Calculate the cost/ton CO2 saved

1. Simulate Current distributions for 10 years
   - Miles per trip & Miles per gallon
2. Calculate the gas we will save & electricity use
   - Separately for each vehicle
   - For different percentage of the fleet being converted
     - Assuming a vehicle can take only 1 trip every other day max
   - Different algorithms for Battery Electric and Plug in Hybrids vehicles

Simulated Distributions for 10 Years of Car Usage



Battery electric vehicle	Plug in hybrid vehicle
IF Miles per trip < Range Find Electricity needed Find Gas that would of been used (Miles per trip/Miles per gallon)	**IF** Miles per trip < Range Find Electricity needed Find Gas that would of been used (Miles per trip/Miles per gallon) **IF** Miles per trip > Range Find Electricity needed to go the range Find Gas that would of been used to go the range (Range/Miles per gallon)

3. Calculate the cost/ton CO2 saved
   - Cost to upgraded fleet
   - The CO2 production eliminated
   - Plotted the data based on percentages

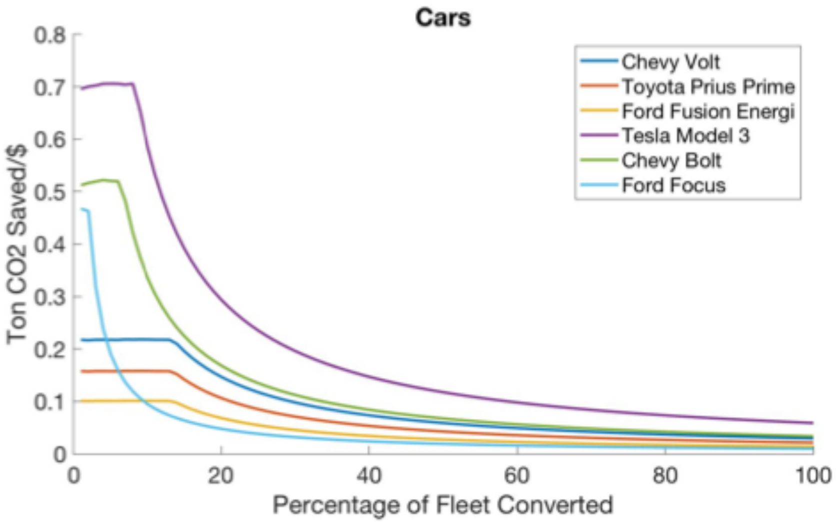
Results & Recommendations

Results

- Curves for $/Ton C02 Saved were made for each vehicle
  - This plot shows Tesla Model 3 is the ideal
- Different plots for different category of vehicles
- Comparison of vehicle quality

Recommendations

- Use the curves generated to compare electrifying the fleet to other green projects
- Optimization with the rest of cornell is required
- Use one charger per vehicle to maximize the savings



Note: Linearity is caused by the constant utilization assumption

Future Scope of Work

- Update vehicle utilization via research/modeling
  - We assumed 50% utilization
- Optimize number of charging stations
  - We assumed 1 charging station per vehicle
- Determine locations for charging stations
  - We envision charging stations to be in parking lots where EVs will be stored overnight
- Constrain model with additional information
  - Expected time frame for simulation, budget constraints, and others
- Continue to monitor EV industry to make updates for EV selection