ME 595/695 Electric Vehicles:
Halfway Project: Porsche Taycan

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Agenda

Introduction | Methods | Results | Conclusions

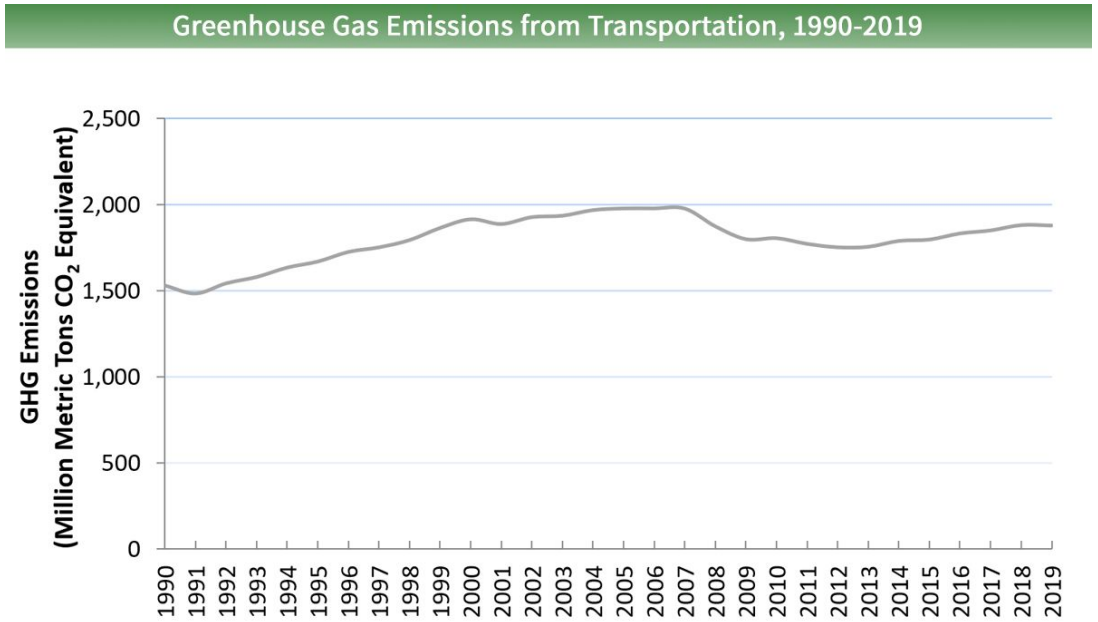
- Introduction
  - CARB and EPA
  - Greenhouse Emission
- Methods
  - Real-World Vehicle
  - Component Analysis
- Results
  - Component Modeling
  - FastSim Modeling
  - Real-World Data
- Conclusions
  - Next Phase Planning

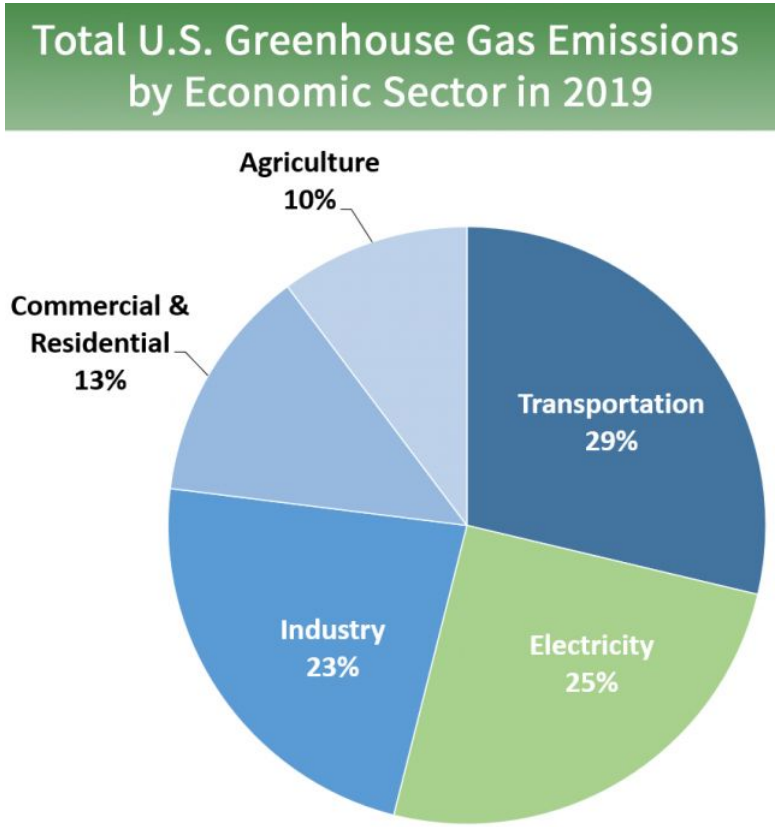
Regulations

- California Air Resources Board (CARB)
  - Established in 1967
- Environmental Protection Agency (EPA)
  - Established in 1970

Greenhouse Emissions

- ICE emissions
  - HC, CO, NO_x
  - CO_2 - majority
- Emission by sector
  - Transportations

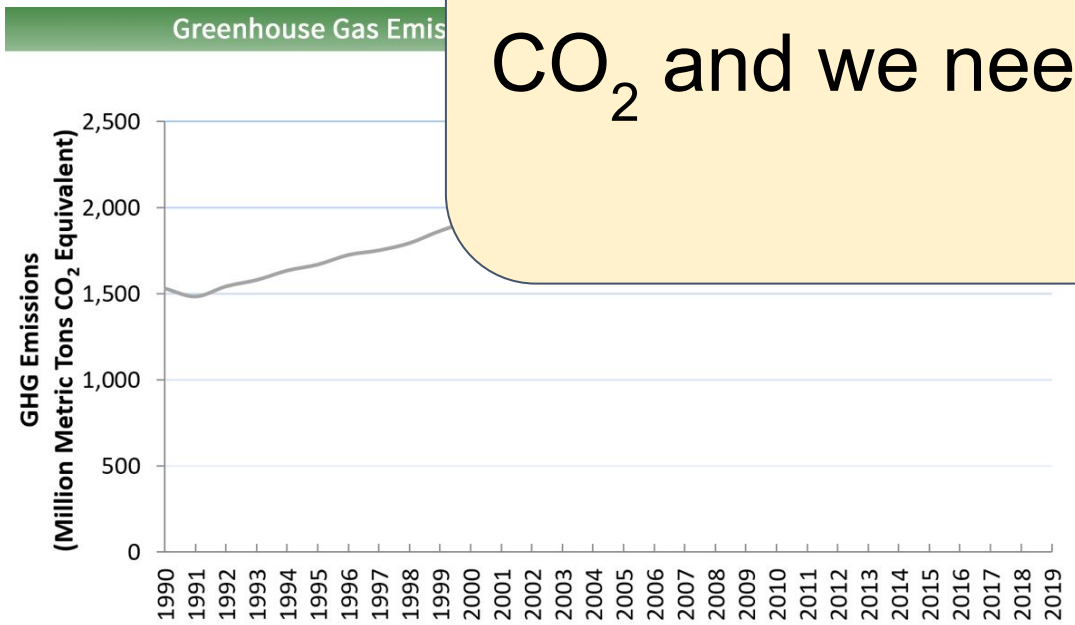


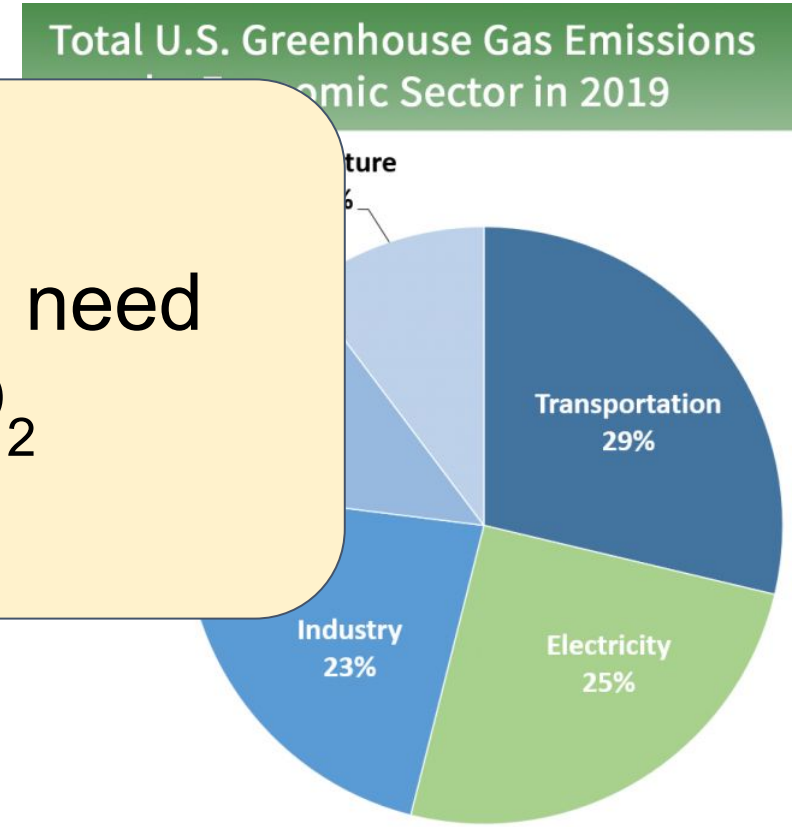


Greenhouse Emissions

- ICE emissions
  - HC, CO, NO_x
  - CO_2 - majority
- Emission by sector
  - Transportations

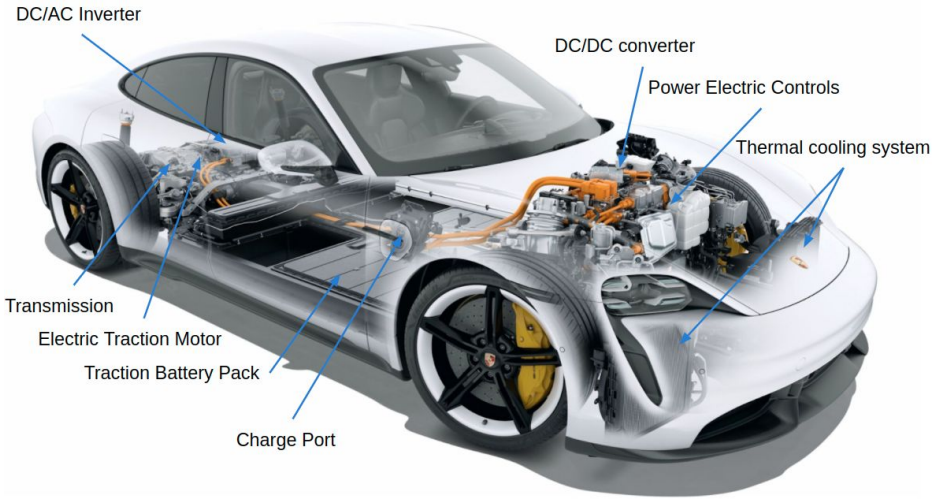
Remember that tree need CO_2 and we need O_2





Real-World Vehicle

- Porsche Taycan
  - Innovative Features.
    - 800 Volt Battery System
    - Front axle and rear axle motors.
    - Two speed transmission
  - Major Specifications
    - Curb Mass: 4567 lb
    - Cv Value: 0.22
    - City Range: 460 - 512 km
    - Highway Range: 385 km
    - Gross Battery Capacity: 93.4 kWh
    - Net Battery Capacity: 83.7 kWh
  - Performance Specifications
    - 0 - 60 mph: 5.1 s
    - Power Output: 402 hp
    - Top Speed: 143 mph



Component Analysis: Battery

- Battery Voltage

$$V_b = N_{cells,s} \times V_{cell,max}$$

$$V_b = 198 \times 4.2V = 831.6V$$

- Coulometric Capacity

$$C_c = N_{packs,p} \times E_{charge}$$

$$C_c = 2 \times 64.5Ah = 129Ah$$

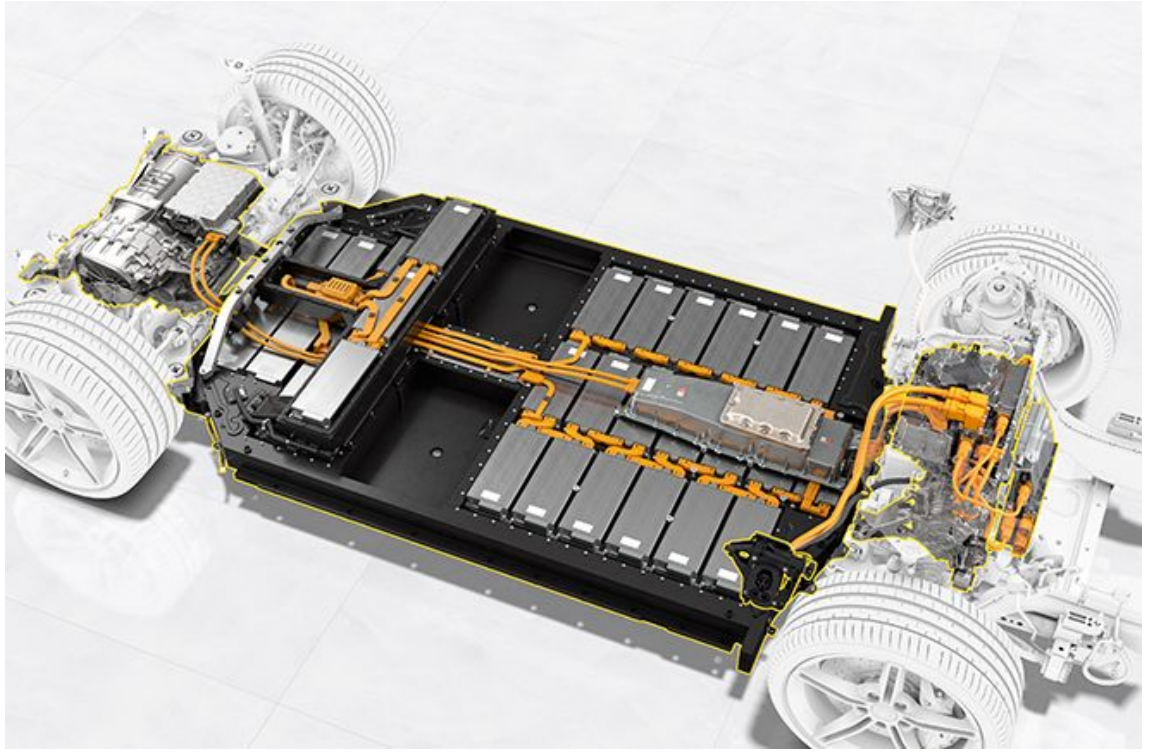
- Battery Capacity

$$E_b = C_c \times V_{nom} \times N_{cells,s}$$

$$E_b = 129Ah \times 3.7V \times 198 = 94.5kWh$$

- Current Draw (Ah)

$$\Delta C_c = \int_{t_o}^{t_f} i(t)\,dt \text{ , where } i(t) = 0.295 \times velocity$$

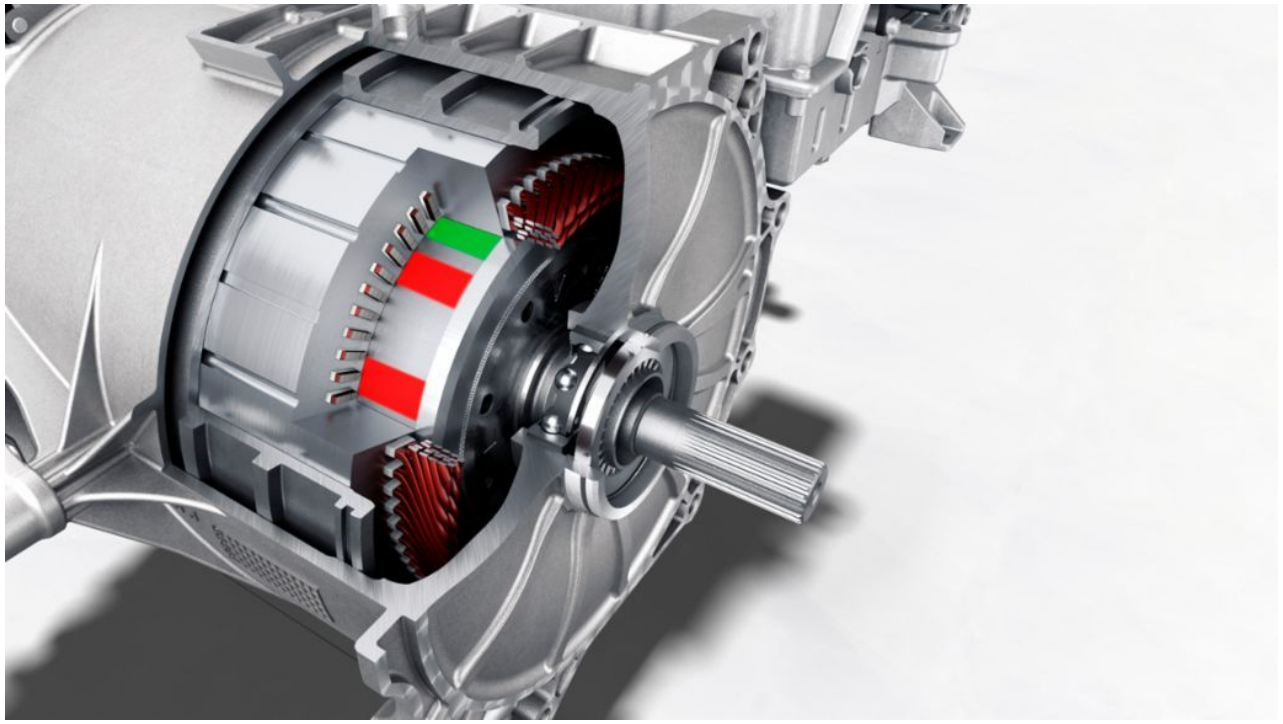


Component Analysis: Motor

- 2 PSM
- Power: 420 kW
- Torque: 650 Nm

$$T_m = X_{\theta_m} \times \frac{P^*_m}{w_m}$$

$$P_m = X_{\theta_m} \times P^*_m$$



Component Analysis: Power Electronics

- Electrical Vehicle Manager
  - Driving range calculations
  - High-voltage battery charging management
  - Energy flow management
  - Brake booster control

- Interaction between Driver and ECU

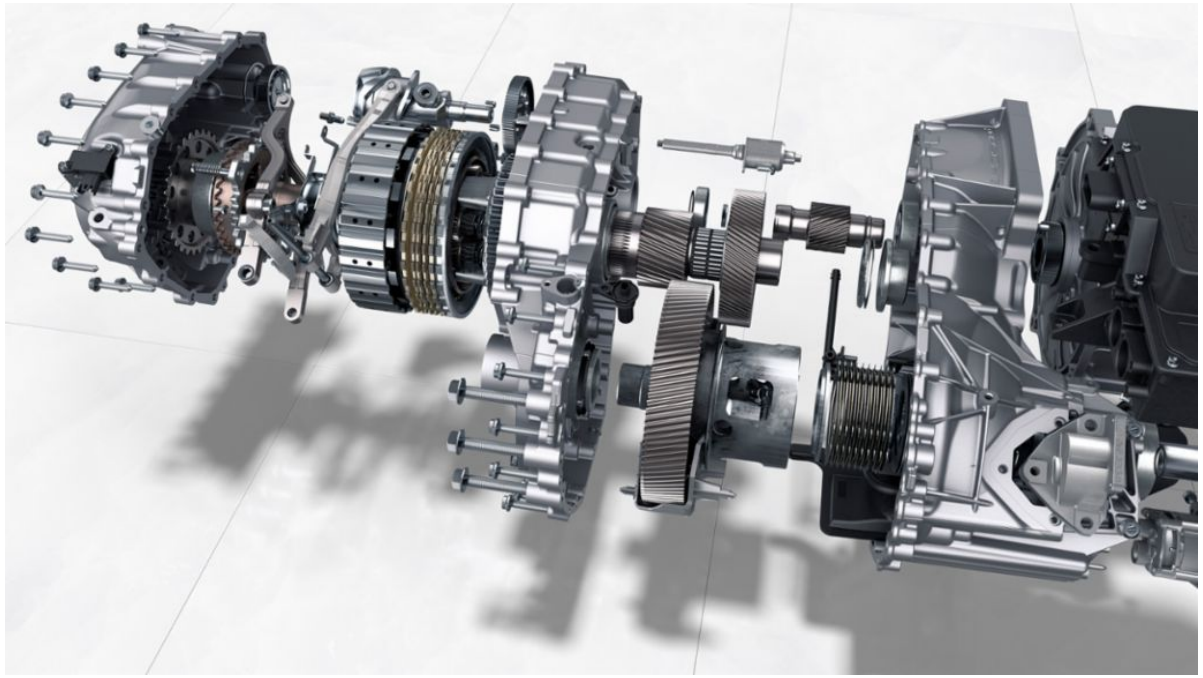
Component Analysis: Drivetrain

- Transmission: 2-speed
  - 1st == 15:1
  - 2nd == 8:1

$$\frac{W_{out,1}}{W_{in,1}} = 15{:}1$$

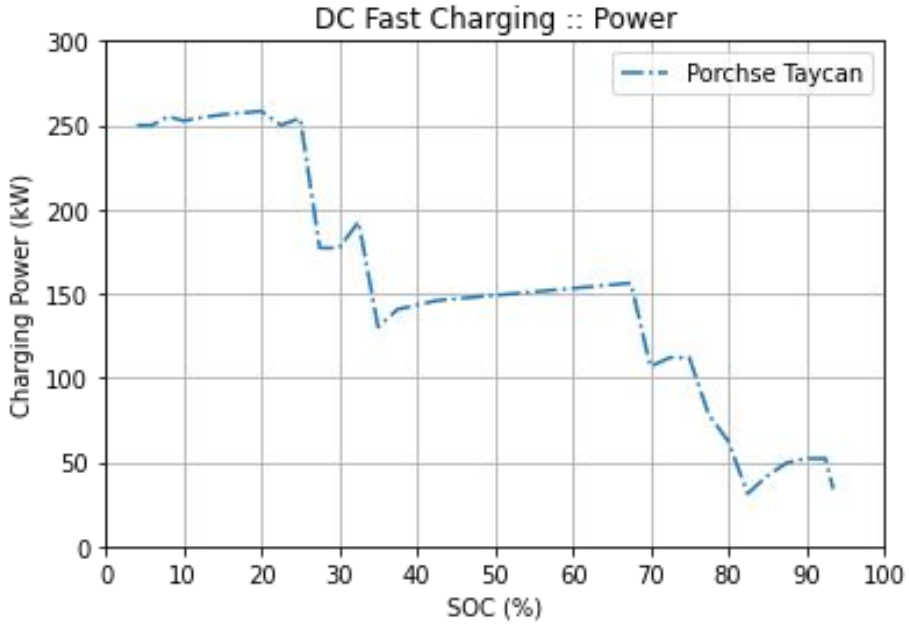
$$\frac{W_{out,2}}{W_{in,2}} = 8{:}1$$

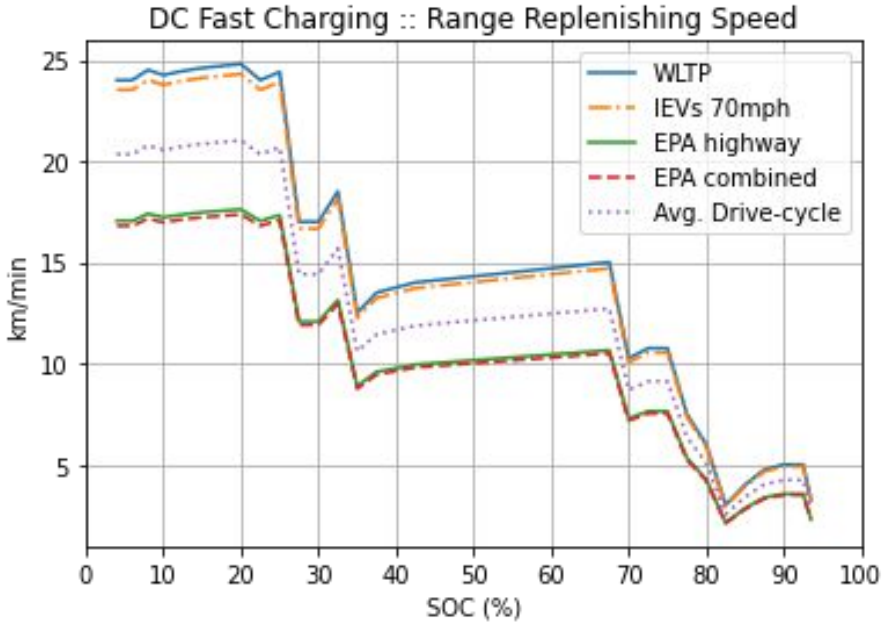
$$W_{rad} = \frac{v}{r}$$



Component Modeling: Battery

- Data found during research[1]
- DC Fast Charging



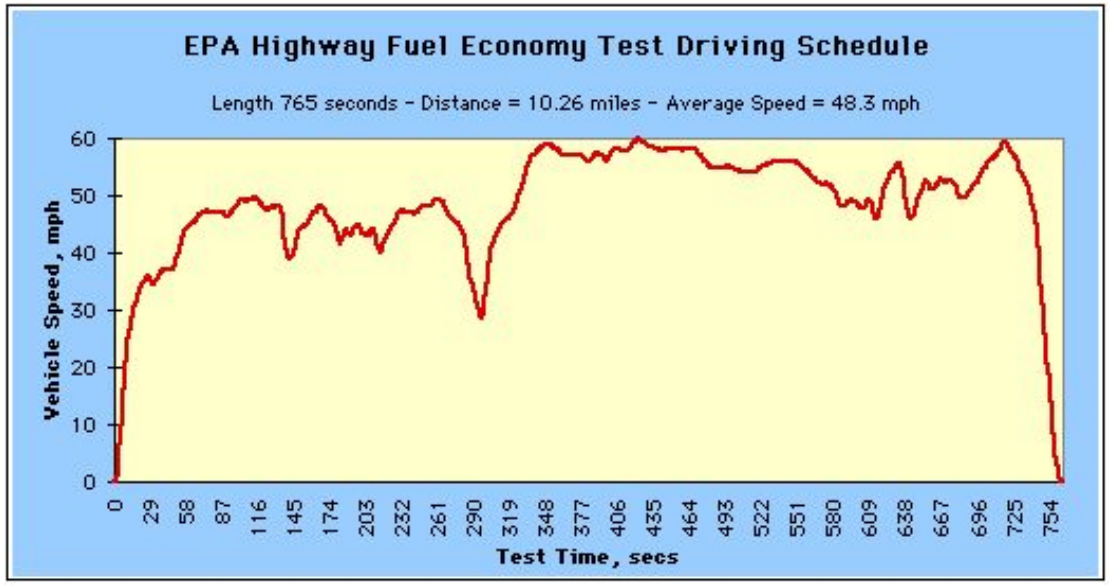


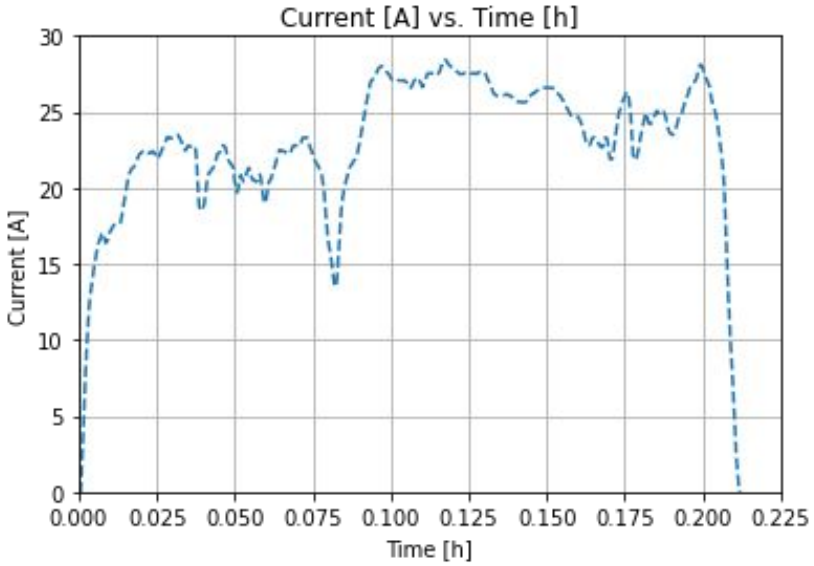
1. https://insideevs.com/news/512344/porsche-taycan-fast-charging-analysis/

Component Modeling: Battery

- HWFET Drive cycle used to get the change in current
  - Current is proportional to velocity at a given point in time

$$i(t) = 0.295 \times velocity$$

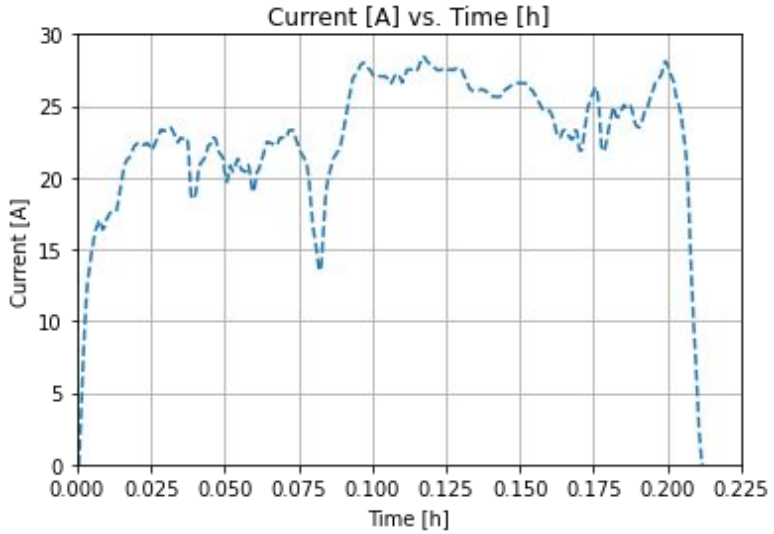


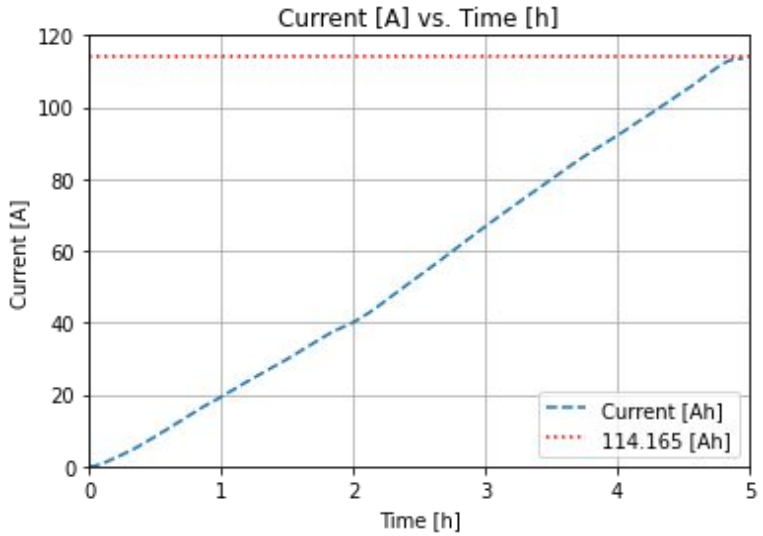


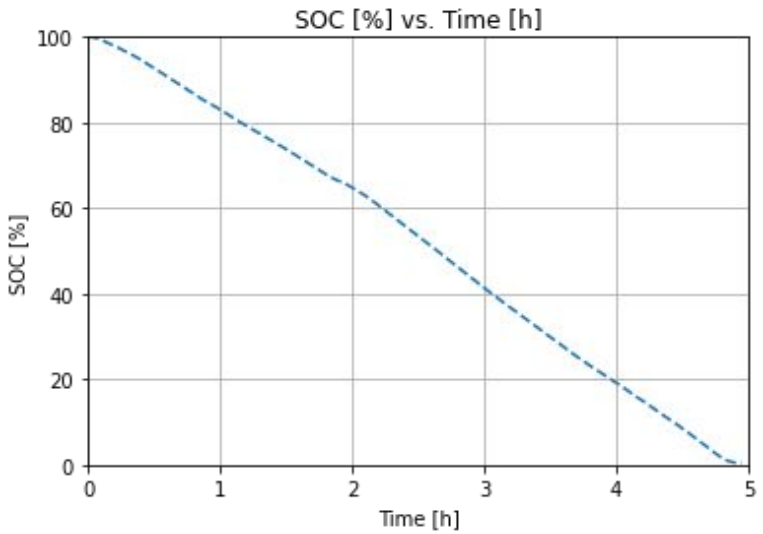
Component Modeling: Battery

- HWFET Drive-cycle used to model current vs. time
- Integrated to get cumulative sum of current used
- Used to calculate the SOC over the Drive-cycle
- Assume:
  - Constant Voltage

$$\Delta C_c = \int_{t_o}^{t_f} i(t)\,dt \text{ , where } i(t) = 0.295 \times velocity$$





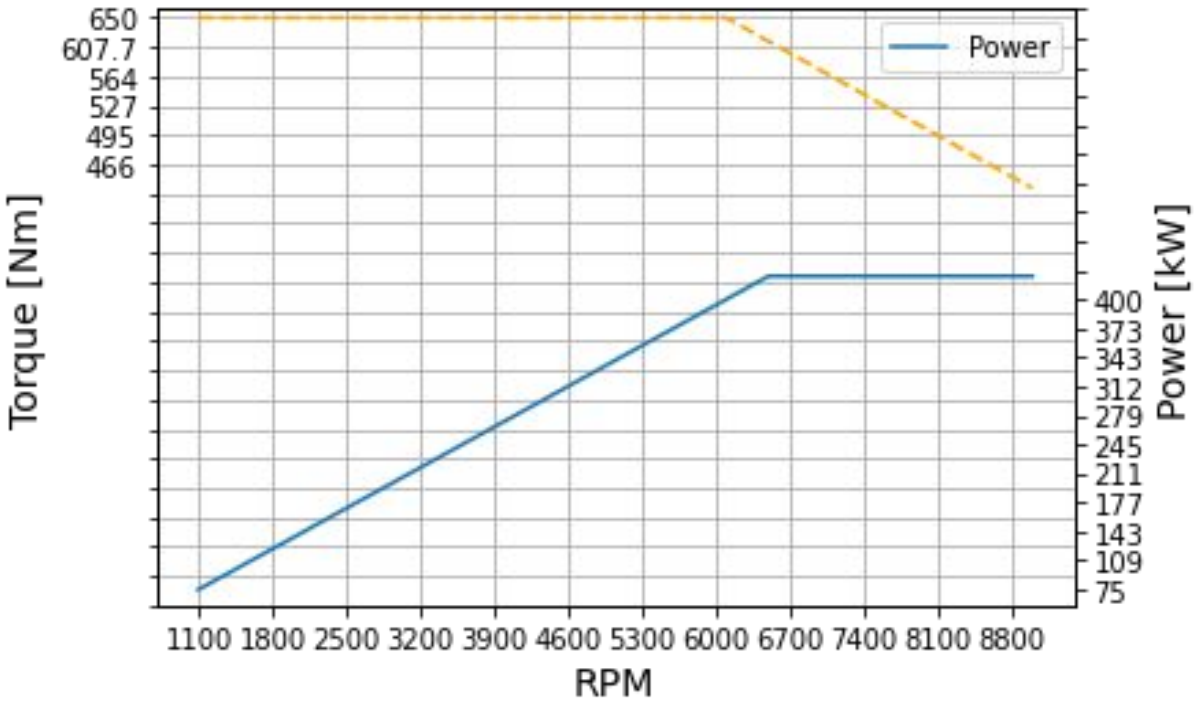


Component Modeling: Motor

- Assumptions:
  - X_{θ} = 100%
  - P_m = 401 kW
  - W^* = 6,500 RPM

$$T_m = X_{\theta_m} \times \frac{P^*_m}{w_m}$$

$$P_m = X_{\theta_m} \times P^*_m$$

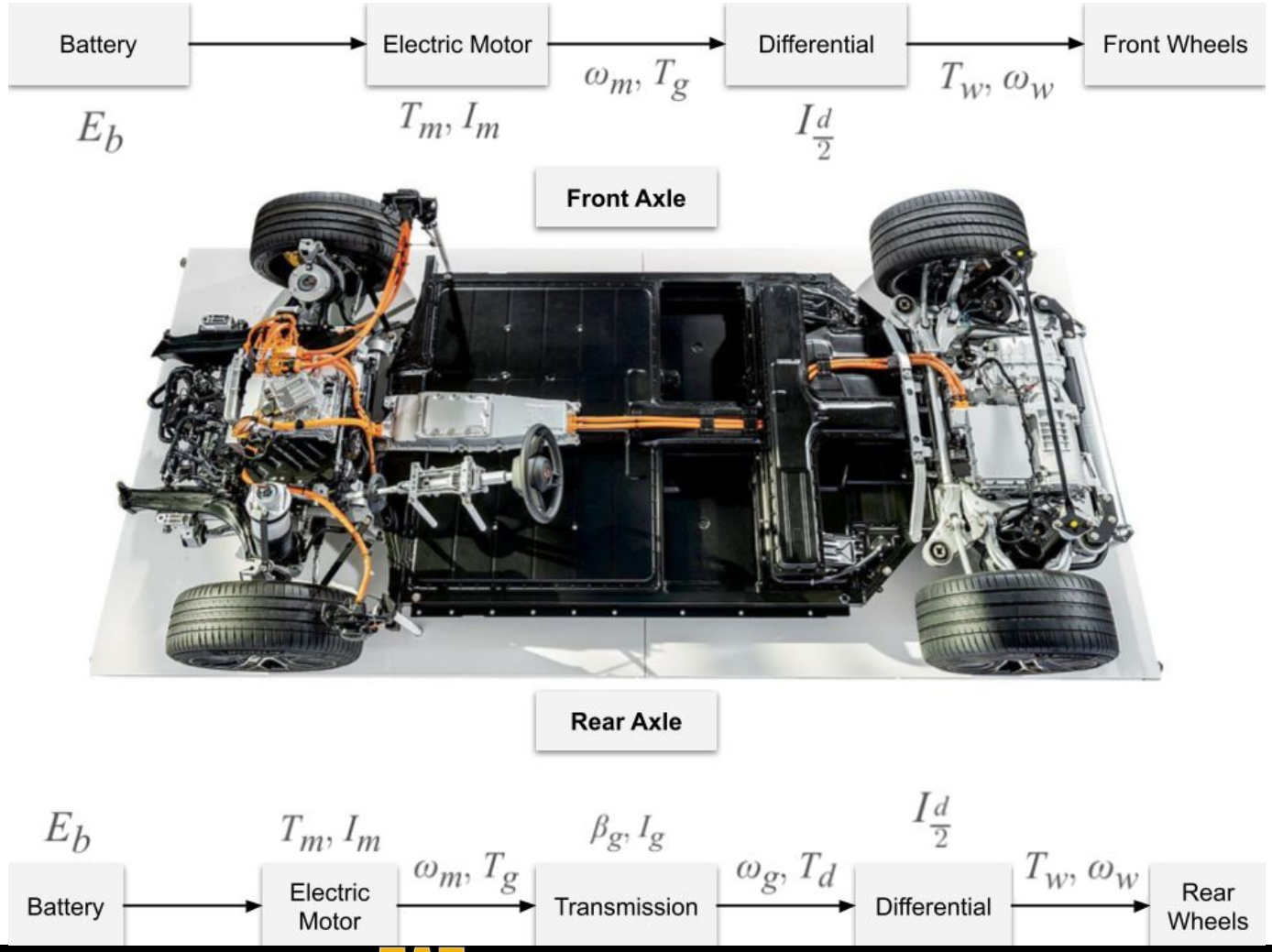


Component Modeling: Drivetrain

- Transmission Modeling using Python
- Using the top speed of the transmission and the gear ratios to derive gear speed

Component Modeling: One Cohesive Vehicle

- Forward Looking
  - Battery to Wheels
- Backward Looking
  - Wheels to Battery



Component Modeling: FastSim

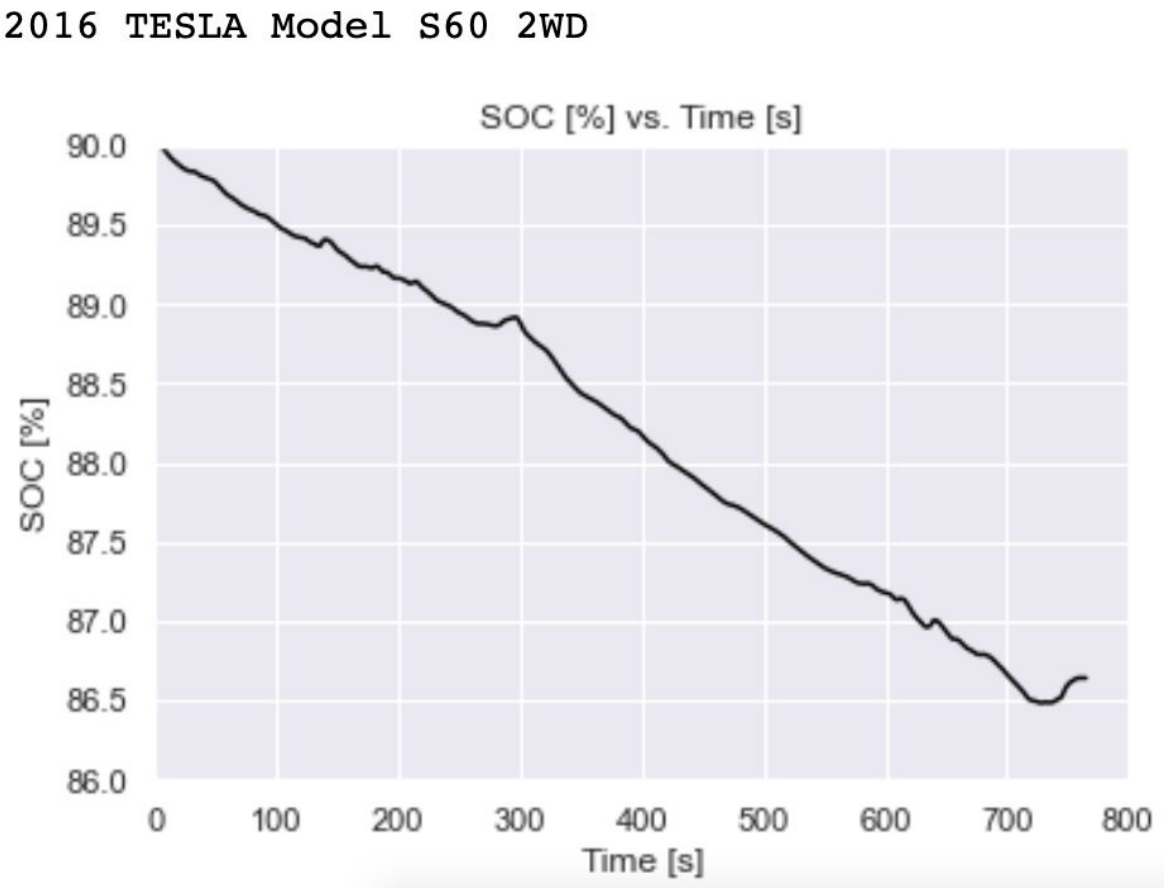
- Tesla Model S60 2WD
  - HWFET drive cycle
    - SOC vs Time
  - Most closely represents Taycan

Battery and Charging

Range EPA	**210 miles (338 km)**
Range NEDC	**233 miles (375 km)**
Range WLTP	**N/A**
Battery pack capacity	**60 kWh**
Max charging power (AC)	**22 kW**
Max charging power (DC)	**105 kW**
Avg. charging speed (DC)	**~257 mph**

Powertrain

Accel. 0-60 mph	**5.5 s**
Top speed	**130 mph (210 km/h)**
Engine power	**302 hp (225 kW)**
Engine torque	**317 lb-ft (430 Nm)**
Efficiency	**29 kWh/100 miles**
Drive type	**RWD**
Motor type	**AC-induction**



Real-World Data

Electrical Consumption at various scenarios.

- Low = non-aggressive
- Med = normal
- High = aggressive
- Extra-high = aggressive load
  - Towing, hills

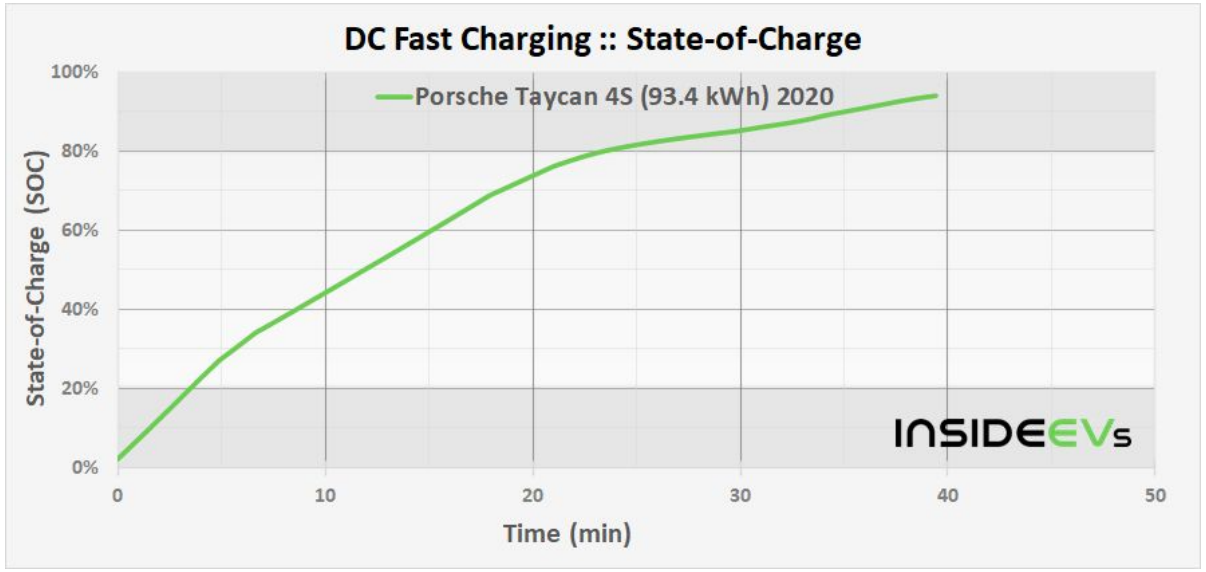
Consumption/Emissions WLTP	
CO2-Emission Combined	0-0 g/km
Electrical Consumption low	22.6 - 19.7 kWh/100km
Electrical Consumption medium	22.0 - 19.1 kWh/100km
Electrical Consumption high	21.6 - 18.2 kWh/100km
Electrical Consumption extra-high	21.3 - 22.1 kWh/100km
Electrical Consumption combined	25.4 - 20.4 kWh/100km
Electrical Consumption city	22.3 - 19.3 kWh/100km

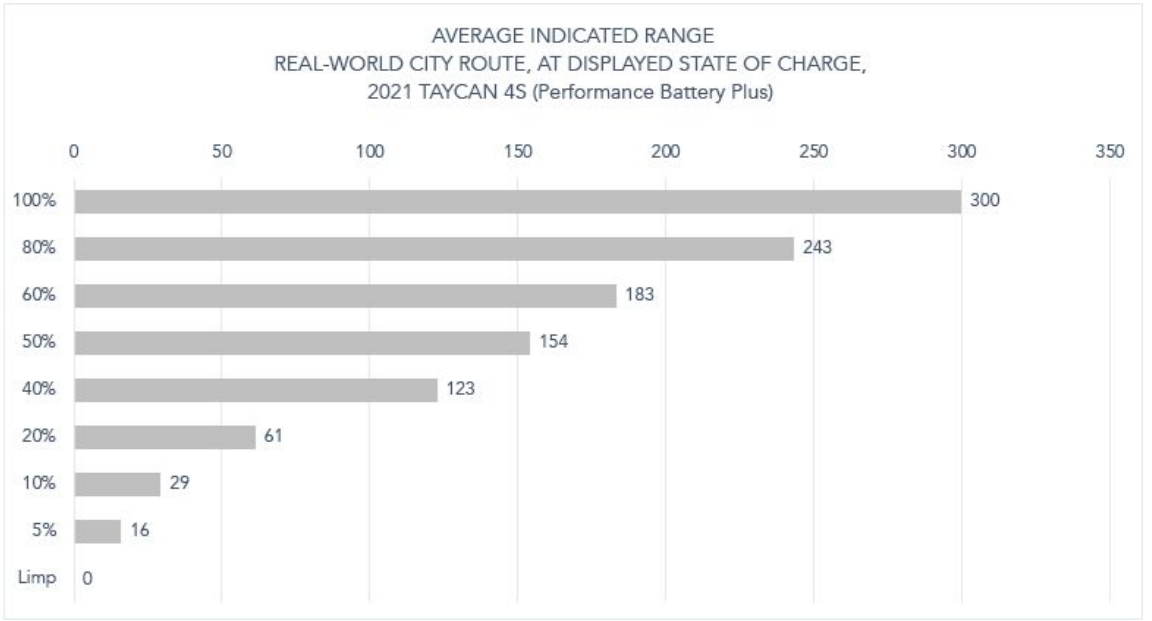
Real-World Data

Introduction | Methods | Results | Conclusions

- Vehicle's Ability to be charged from up to 80% in under 25 minutes.

- Range at given State of Charge.

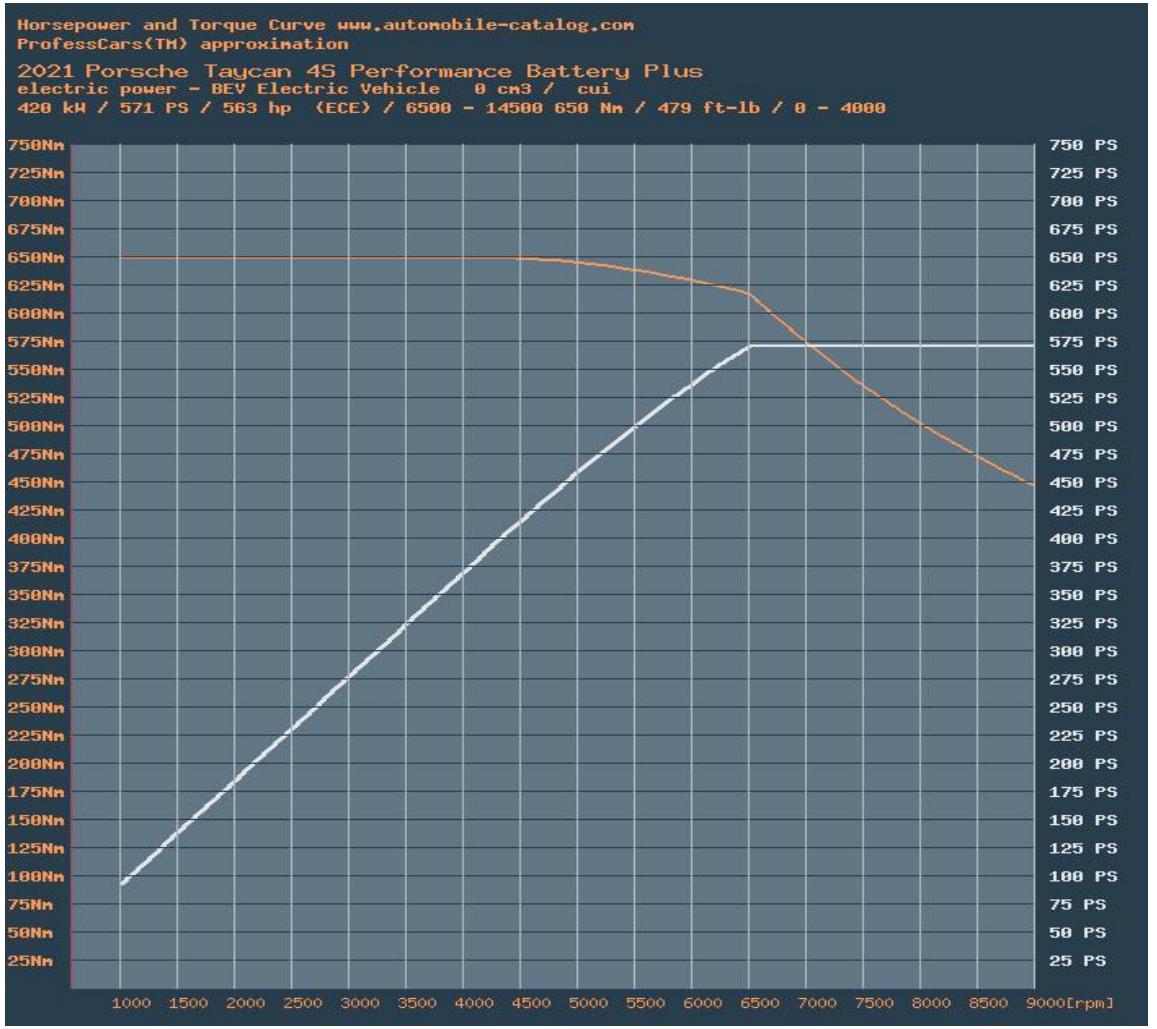




Real-World Data

- A plot of Power and Torque vs Speed shows a maximum power of 420 kW and maximum Torque of 650 Nm.

- Base Speed shows to be around 6500 RPM.



Next Phase Planning

Introduction | Methods | Results | Conclusions

- Need more information
  - Real-world data
  - Simulated date
    - make wild assumptions
- Backward Looking
  - Complete comprehensive