NREL
NATIONAL RENEWABLE ENERGY LABORATORY

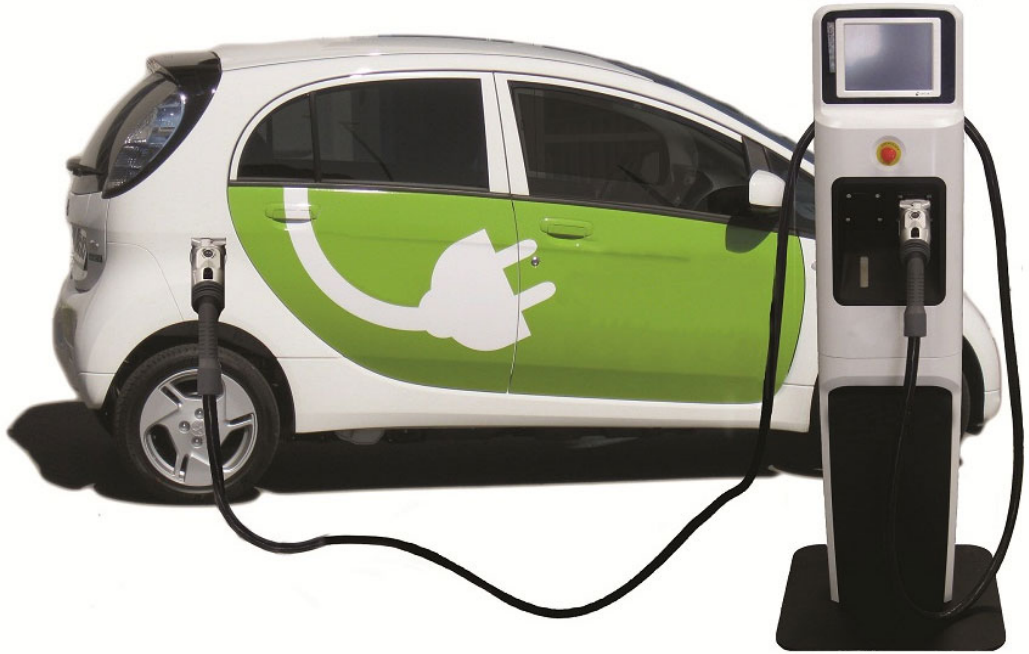
City of Dallas
Fleet Electrification Analysis Update

National Renewable Energy Laboratory
Ken Kelly, Cory Sigler, Matt Jeffers

January 3, 2022

Photo by Gabriel Tovar on Unsplash

Presentation Overview



- Update on City Fleet Electrification Study
- CECAP Action T1 - Supporting Fleet Electrification
- FY 20-21 - Budget Amendment to support CECAP Implementation ($200,000)
- NREL Contract – Council Approval in May 2021
- Project Kickoff in August 2021

NREL at a Glance

2,050

Employees,
plus more than
400
early-career researchers
and visiting scientists

World-class
facilities, renowned
technology experts

nearly
820

Partnerships
with industry,
academia, and
government

Campus
operates as a
living laboratory

NREL Center for Integrated Mobility Sciences

https://www.nrel.gov/transportation/research.html

Hydrogen and Fuel Cells

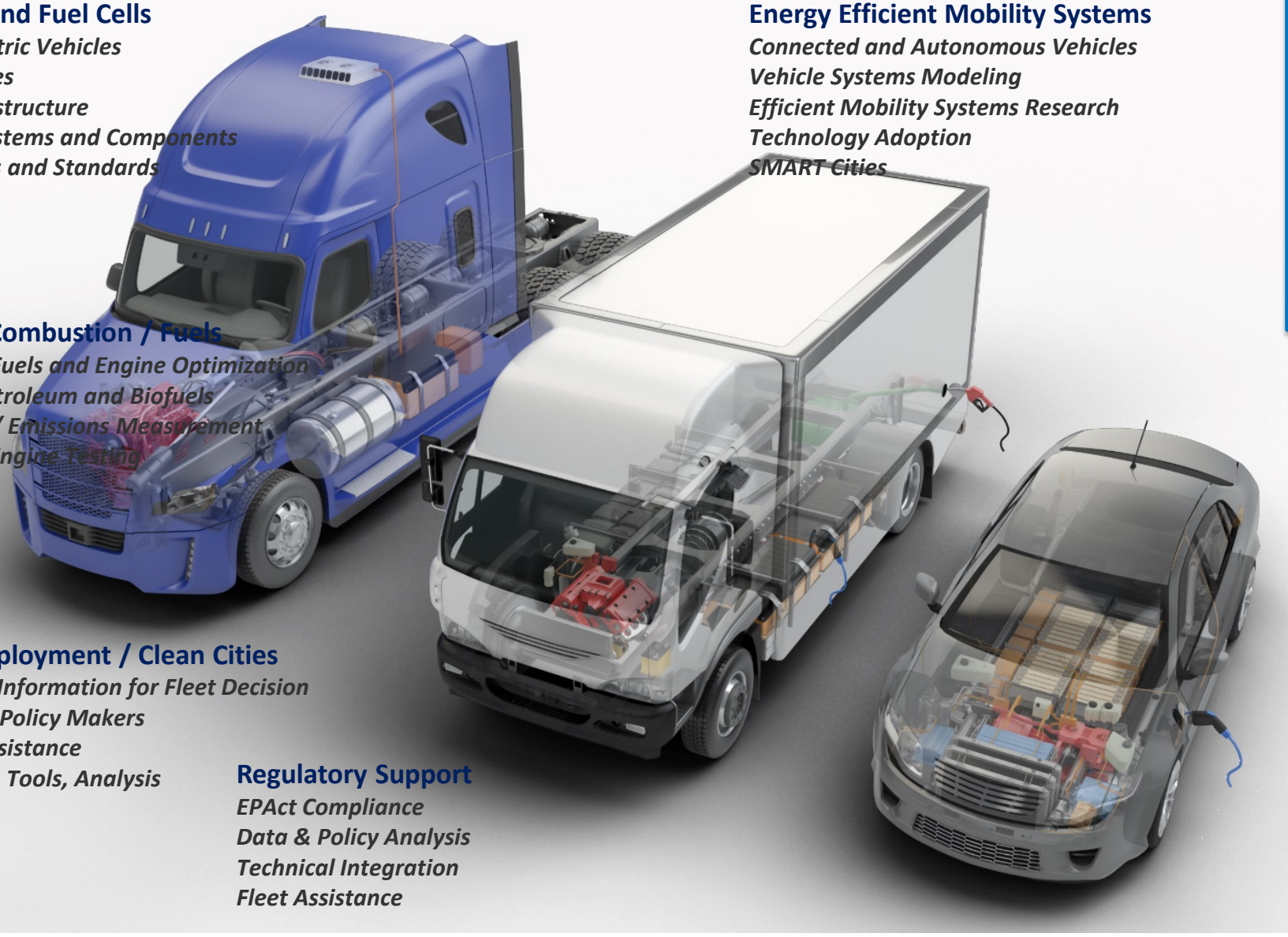
Fuel Cell Electric Vehicles
Fuel Cell Buses
Fueling Infrastructure
Hydrogen Systems and Components
Safety, Codes and Standards

Energy Efficient Mobility Systems

Connected and Autonomous Vehicles
Vehicle Systems Modeling
Efficient Mobility Systems Research
Technology Adoption
SMART Cities

Advanced Combustion / Fuels

CoOptima – Fuels and Engine Optimization
Advanced Petroleum and Biofuels
Combustion / Emissions Measurement
Vehicle and Engine Testing



Vehicle Deployment / Clean Cities

Guidance & Information for Fleet Decision Makers and Policy Makers
Technical Assistance
Online Data, Tools, Analysis

Regulatory Support

EPAct Compliance
Data & Policy Analysis
Technical Integration
Fleet Assistance

Commercial Vehicle Technologies

Technology Field Testing & Analysis
Big Data Collection, Storage & Analysis
Vehicle Systems Modeling
Super Truck and 21st Century Truck
Truck Platooning and Automation
Vehicle Thermal Management

EV Grid Integration

Extreme Fast Charging – 1+ MW
Vehicle-to-Grid Integration
Integration with Renewables
Charging Equipment & Controls
Fueling Stations & Equipment

Mobility Infrastructure & Impacts Analysis

Hydrogen & Energy Storage Analysis
Integrated Transportation & Energy Systems Analysis

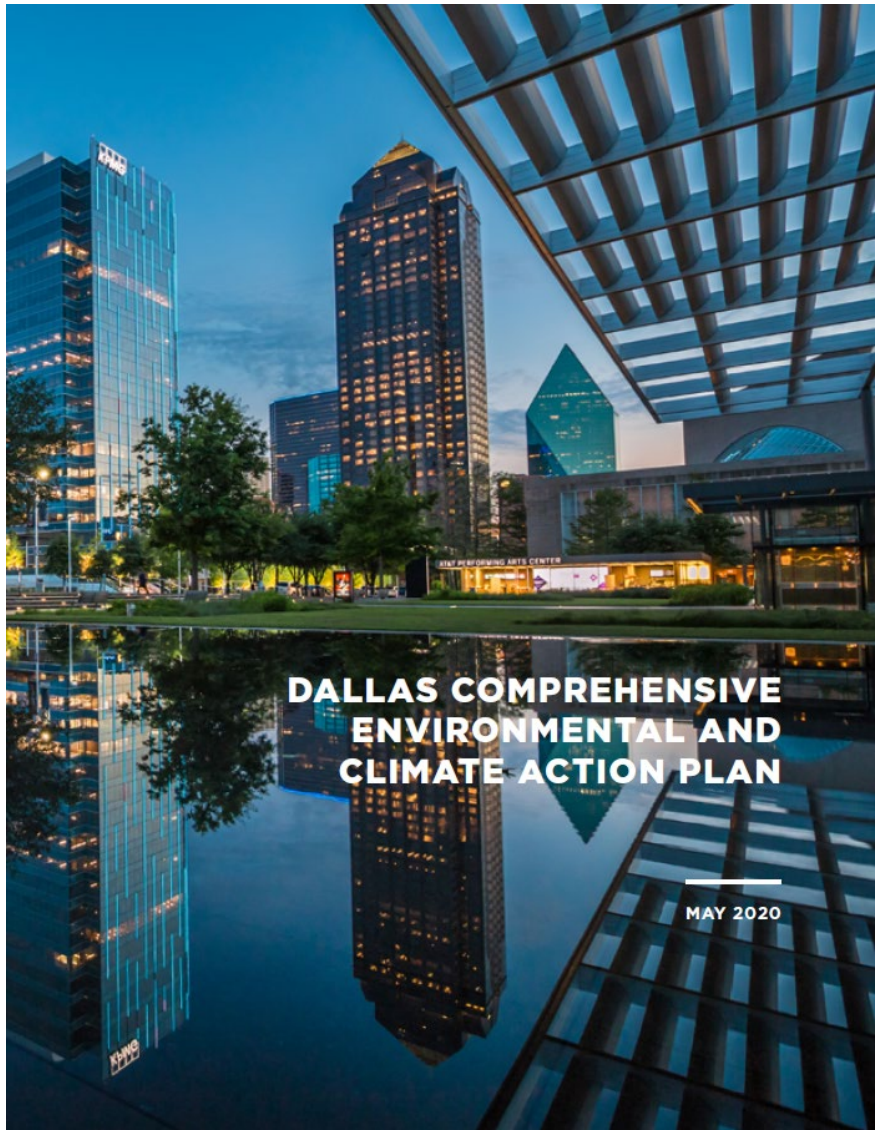
Advanced Energy Storage

Thermal Characterization / Management
Life/Abuse Testing and Modeling
Computer Aided Engineering
Electrode Material Development

Advanced Power Electronics and Electric Motors

Thermal Management
Advanced Heat Transfer
Thermal Stress and Reliability

Dallas Fleet Electrification Goals



- The Intergovernmental Panel on Climate Change (IPCC) recommends **reducing GHG emissions to net zero by 2050** to limit the increase in global temperatures to below 1.5°C.
- The City of Dallas is **committed to meeting the international emission reduction targets** set by the Paris Agreement in 2016.
- The 2015 greenhouse gas (GHG) inventory reported that **35% of Dallas' GHG emissions come from transportation sector.**
- The CECAP provides a roadmap for the City to improve quality of life, **to reduce greenhouse gas emissions**, to prepare for the impacts of climate change, and to create a healthier and more prosperous community.

Dallas Fleet Electrification Goals

TARGETS

INSTALL 1,500 EV CHARGING OUTLETS TO SUPPORT 39,000 VEHICLES THROUGHOUT THE CITY BY 2030.

ALL NEW TRANSIT BUSES AND LIGHT DUTY VEHICLES PURCHASED BY THE CITY, DALLAS SCHOOLS, AND DART AFTER 2030 TO BE FULLY ELECTRIFIED, AND THEN FULL FLEET TRANSITION BY 2040.

SINGLE OCCUPANT VEHICLE TRAVEL MODE SHIFT FROM 88% TO 79% IN 2030 AND 88% TO 62% IN 2050.

SHIFT THE SURFACE TRANSPORTATION SYSTEM TO MOVE PEOPLE AND GOODS IN FUEL-EFFICIENT VEHICLES.

T1. WORK WITH CITY OF DALLAS, DISD, AND DART TO TRANSITION THE BUS AND LIGHT DUTY FLEET TO 100% ELECTRIC BY 2040.

ACTION TYPE
Partnership

ACTION SOURCE
New Action

PRIMARY BENEFIT

Mitigation

CO-BENEFITS

Air Quality

Cost Savings

The City and DART will continue shifting the regional bus and light duty vehicle fleets to 100% EV, transitioning the fleet through new procurement policies and retrofitting older infrastructure and assets to accommodate charging stations on route. The City will work with partners to ensure all new transit buses and light duty vehicles purchased after 2030 will be fully electrified, and then full fleet transition by 2040.

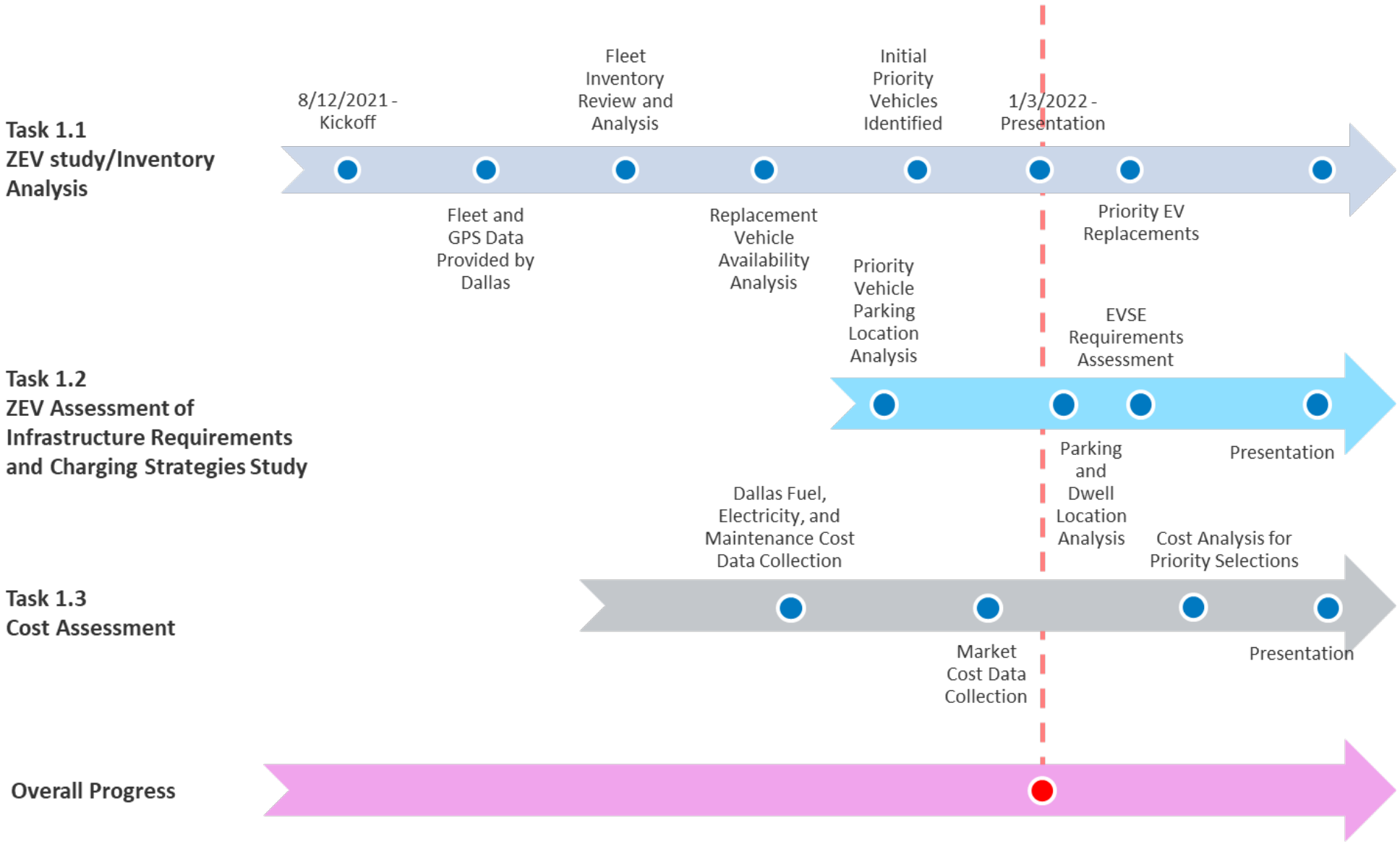
EQUITY CONSIDERATIONS

- This action provides the potential for improved air quality and noise reduction in neighborhoods and communities with more dense and frequent transit service.

Fleet Electrification Considerations

- What are the overall goals of the fleet electrification plan?
- Where are the best opportunities for fuel reduction and emissions reduction?
- Which vehicle duty cycles are suitable for electrification?
- Which vehicles are eligible for electrification (i.e., non-emergency response or special purpose vehicles)
- Which vehicles are nearing retirement or overdue for replacement?
- Which vehicles have an electric model that's commercially available today?
- Which vehicles have dedicated parking spots suitable for charging equipment?
- Which communities or regions of the city stand to benefit the most from lower emissions and improved air quality?

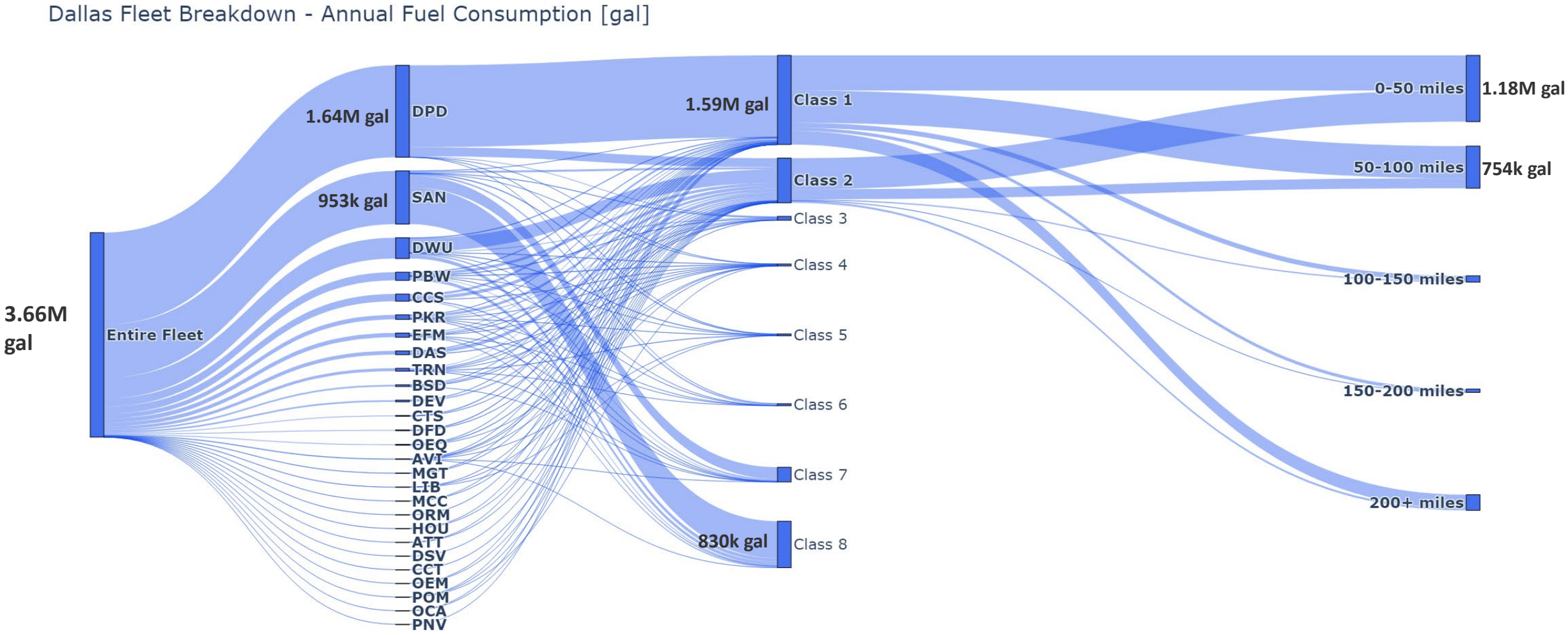
Project Timeline



Dallas Fleet and EV Analysis Summary

Dallas Vehicle Inventory - Sankey Diagram

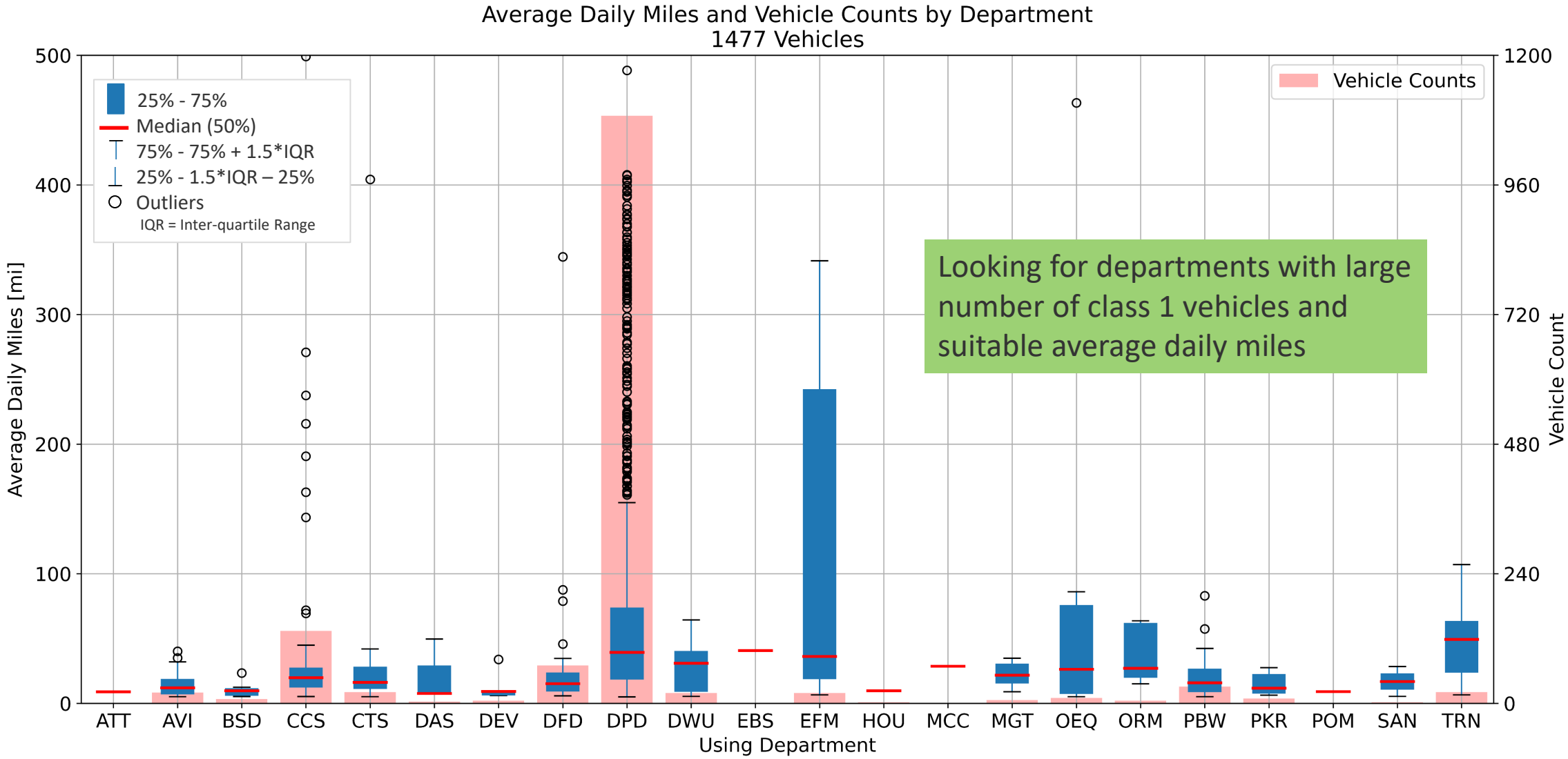
Fleet Breakdown by Annual Fuel Consumption w/ Miles



Open interactive version in browser

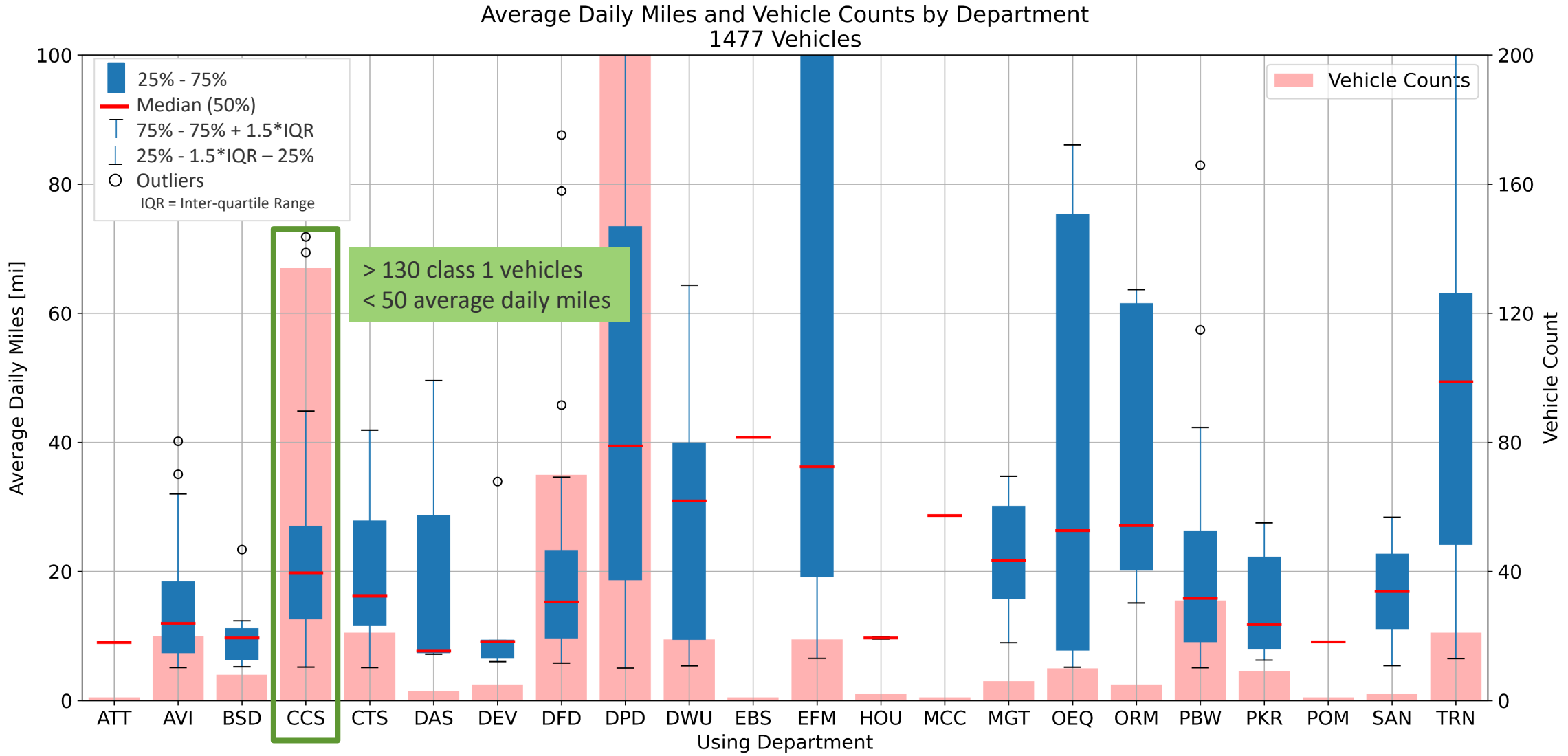
Daily Miles and Vehicle Counts by Department

Class 1



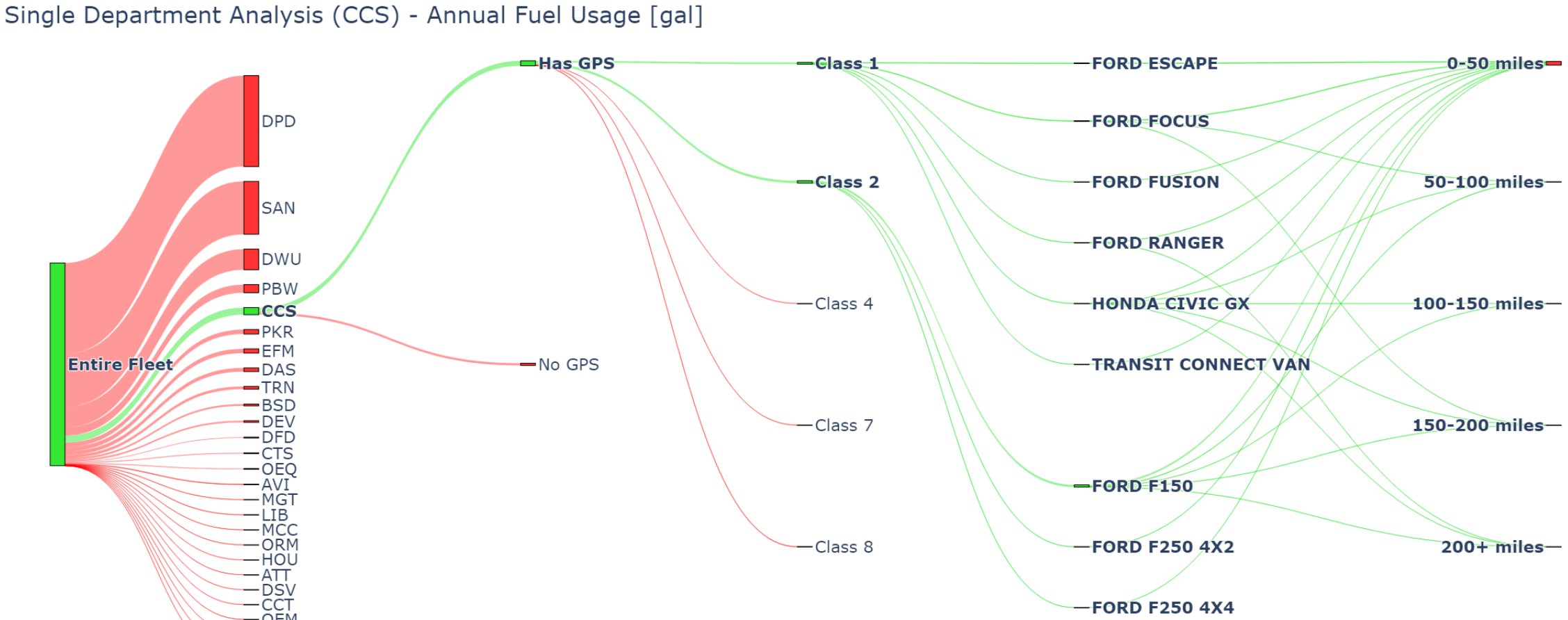
Daily Miles and Vehicle Counts by Department

Class 1 - ZOOMED



Dallas Vehicle Inventory - Sankey Diagram

Example Process by Annual Fuel Consumption



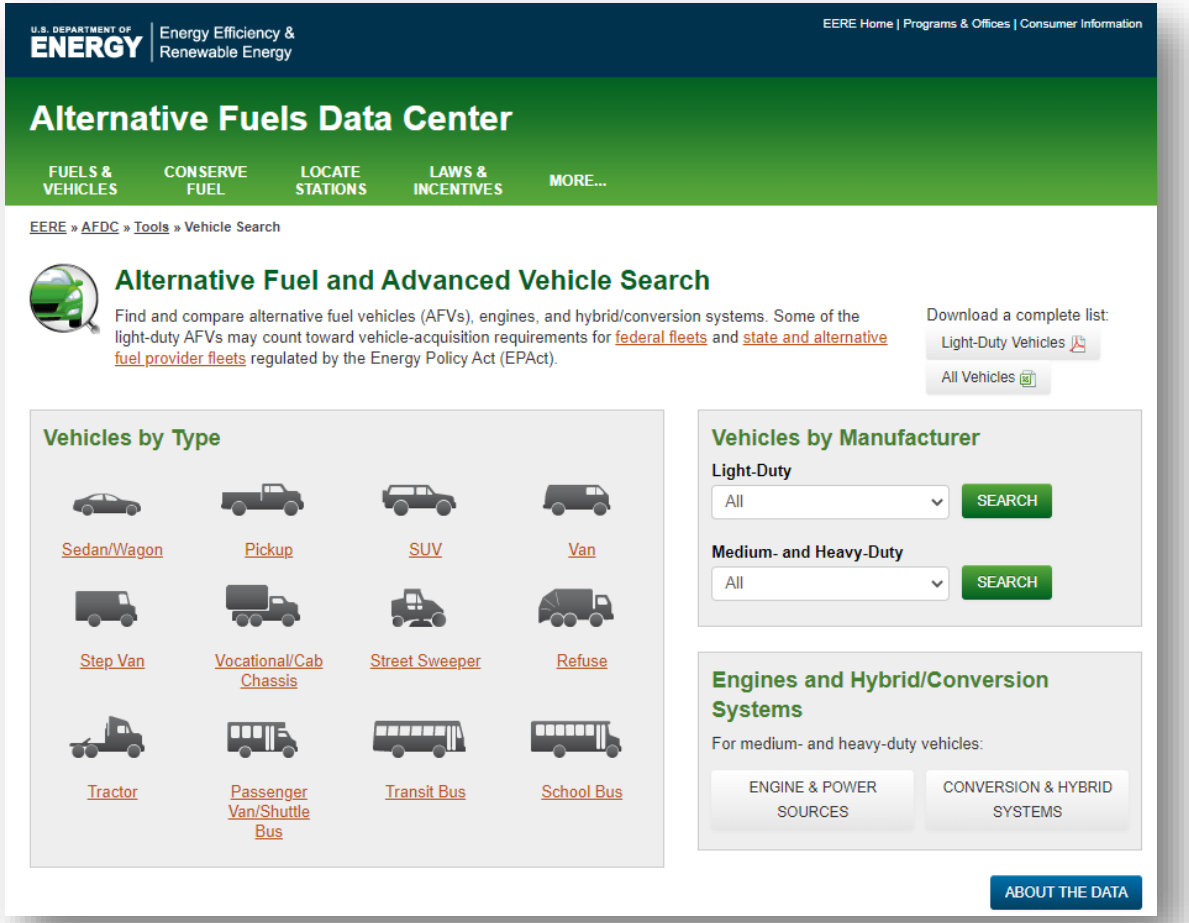
CCS

- Class 1: 128 vehicles, 32,500 gallons
- Class 2: 71 vehicles, 45,100 gallons

Open interactive version in browser

Commercially Available EVs

- Utilized Alternative Fuels Data Center (AFDC) Advanced Vehicle Search tool to find EVs currently on the market
- Filtered list for
  - All-electric (EV)
  - Plug-in hybrid electric (PHEV)



https://afdc.energy.gov/vehicles/search/

AFDC – Electric Vehicles

Sample of EVs available in auto market today

- Class 1 and class 2 vehicles
- EVs and PHEVs
- Excluded high-cost luxury and performance vehicles
- Excluded new and non-mainstream vehicle manufacturers

https://afdc.energy.gov/vehicles/search/

All-Electric (EV)				
Category	**Manufacturer**	**Model**	**Model Years**	**All Electric Range (mi)**
Sedan/Wagon	BMW	I3	2020-2021	153
Sedan/Wagon	Chevrolet	Bolt EV	2020-2022	247-259
Sedan/Wagon	Ford	Mustang Mach-E	2021	211-305
Sedan/Wagon	Hyundai	Ioniq Electric	2020-2021	170
Sedan/Wagon	Kia	Nero Electric	2020-2022	239
Sedan/Wagon	Mini	Cooper SE	2020-2022	110-114
Sedan/Wagon	Nissan	Leaf	2020-2022	149-226
Sedan/Wagon	Tesla	Model 3	2020-2021	220-353
Sedan/Wagon	Volkswagen	e-Golf	2020	123
SUV	Audi	e-tron	2020-2021	218-222
SUV	Hyundai	Kona Electric	2020-2022	258
SUV	Volkswagen	ID.4	2021	250-260
SUV	Volvo	XC40 Recharge	2021-2022	208-223
Van	Ford	Transit (cargo)*	2020	60-120
Van	Ford	Transit (passenger)*	2020	60-120

Plug-in Hybrid Electric (PHEV)				
Category	**Manufacturer**	**Model**	**Model Years**	**All Electric Range (mi)**
Pickup	Ford	F-150*	2020	
Pickup	Ford	Super Duty F-250*	2020	
Sedan/Wagon	Ford	Fusion	2020	26
Sedan/Wagon	Honda	Clarity	2020-2021	48
SUV	Ford	Escape PHEV	2020-2021	37-38
Van	Chysler	Pacifica Hybrid	2020-2021	32

**available with power train developed and installed by an approved qualified vehicle modifier (QVM)*

Emerging Electric Vehicles

Other EV make/models on “watch list”, production models coming soon

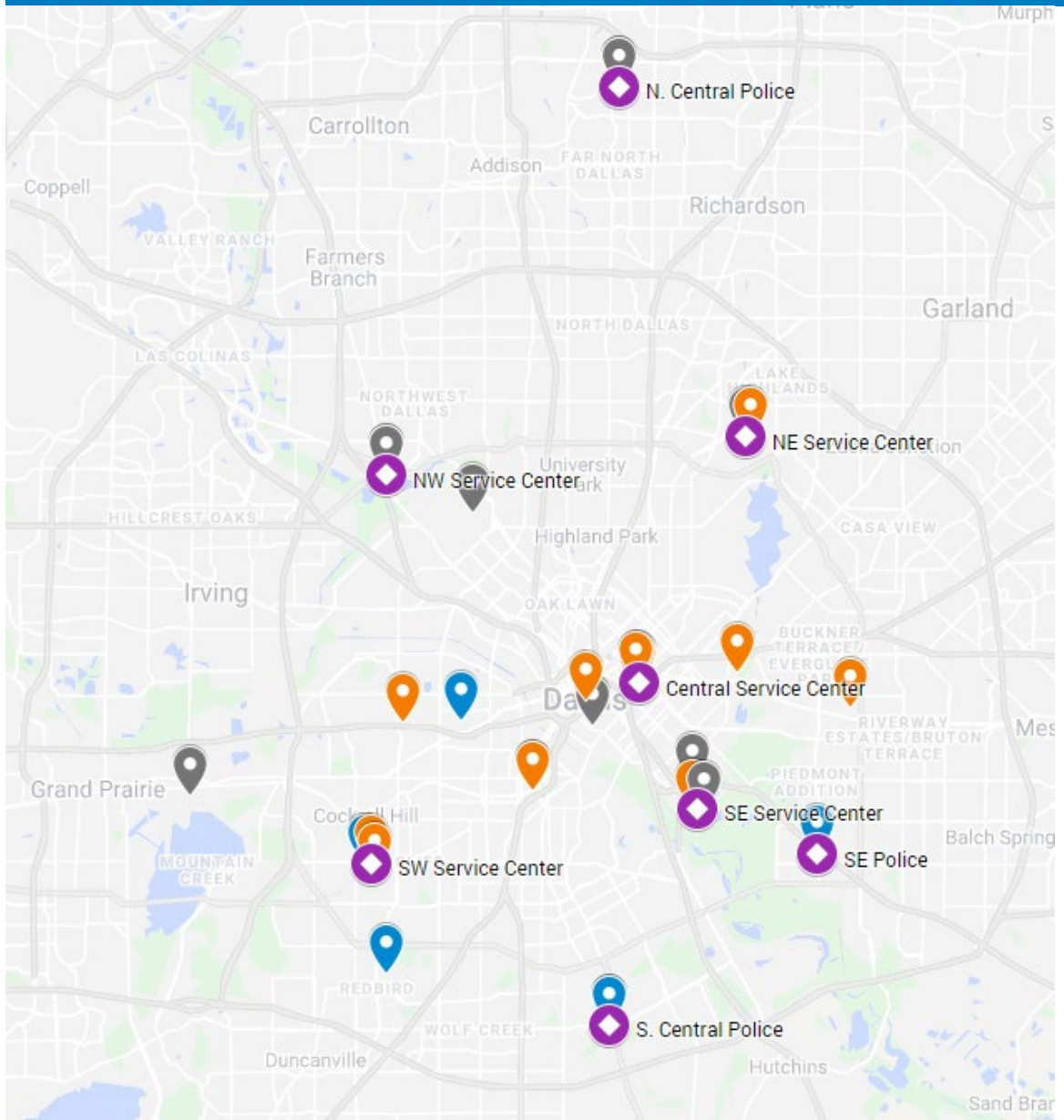
- Ford F150 Lightning EV pickup truck
- Nikola Badger EV pickup truck
- Ford Transit electric van
- Rivian electric van
- GM EV600 electric van

Heavy-Duty EV / PHEV

Heavy-Duty EV / PHEV
- Freightliner eM2
- BYD Refuse Hauler
- Mack LR Refuse Hauler
- Pierce Volterra Pumper

Transit
- Proterra
- BYD
- New Flyer
- Gillig

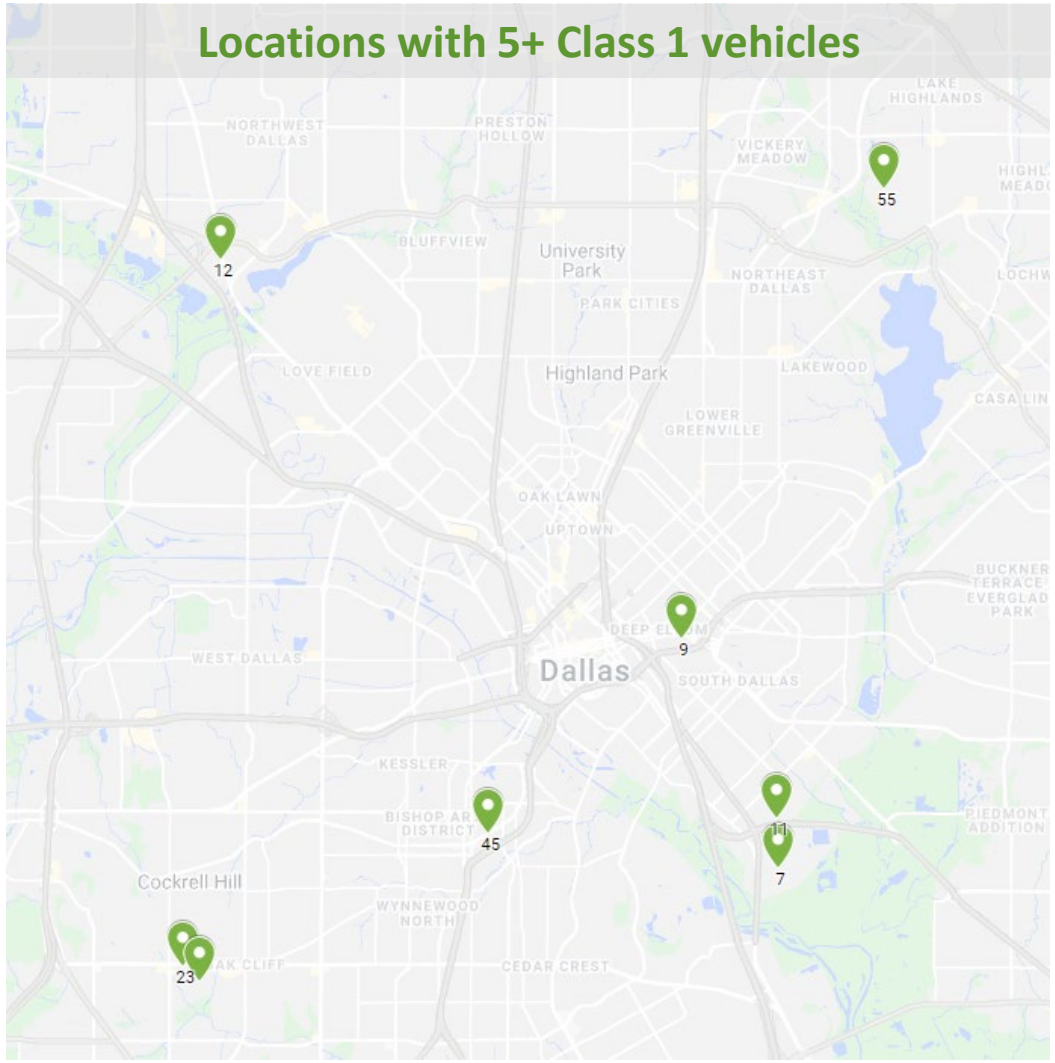
Charging Infrastructure – Parking & Fueling Locations

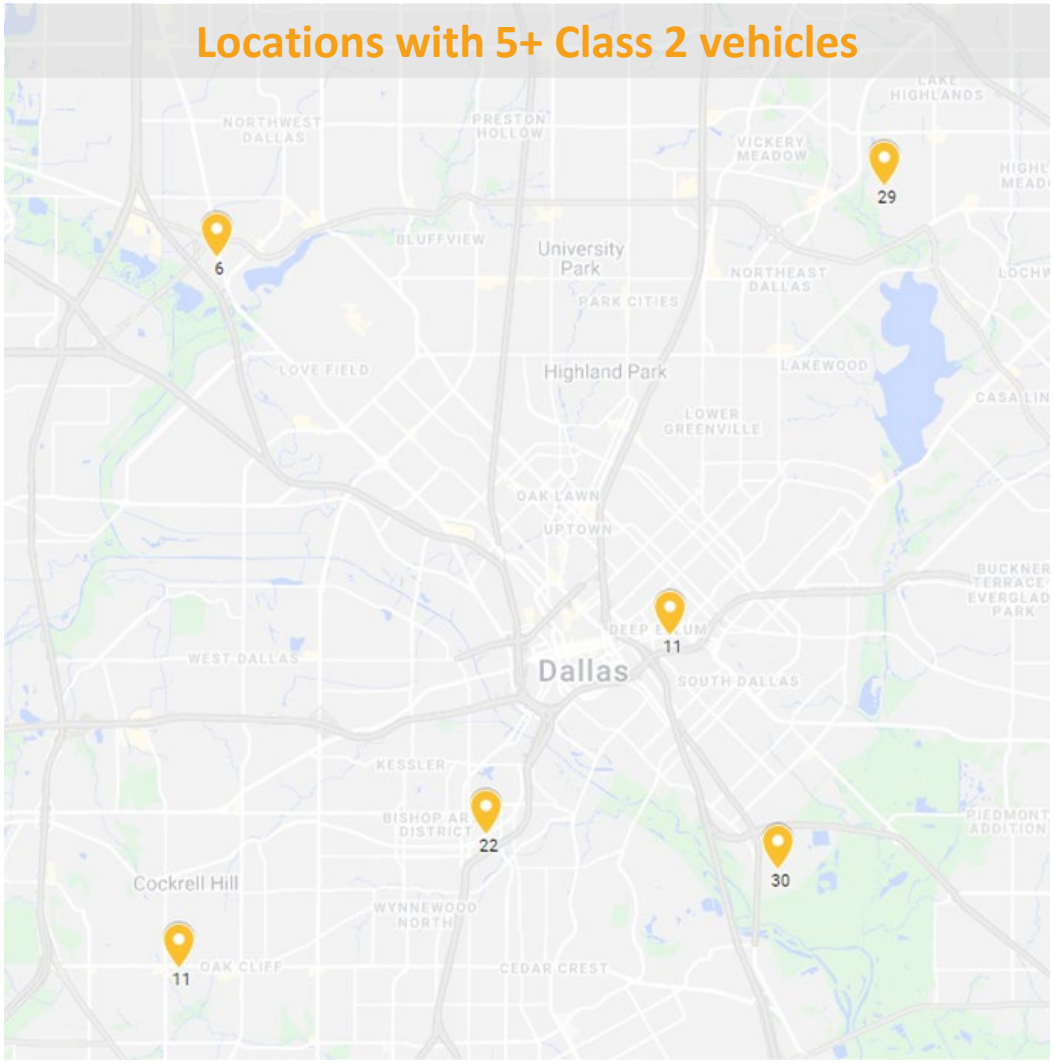


- Reviewed fuel island locations and all parking locations listed in vehicle inventory
  - Identified locations with 5 or more class 1 vehicles
  - Separated PDP locations
  - Following up to refine list and identify duplicate locations

Purple pins – Fueling locations
Blue pins – PDP parking locations
Orange pins – all non-PDP parking locations
Gray pins – other parking (need additional info)

CCS Parking Locations – Class 1 & 2





Initial Qualitative Considerations

Light-Duty EV

- Established market, experience, dealer network
- Standardized EVSE – level II , DC Fast Charge, managed charging
- Likely to find matches with existing LDV functions

Medium-Duty EV

- Emerging product offerings, supply network
- Expected to develop/expand in 2-5 year time frame
- Fleet pickups and vans often require specialty “work” functions

Heavy-Duty EV

- Emerging product offerings, supply network
- Expanded EV products expected in 2-5 year time frame
- Higher charging power / infrastructure investment
- Good opportunity for limited demonstration
- Potential lessons learned from transit EV applications

Initial Takeaways

- ***Data-driven approach*** to fleet electrification strategies
- Dallas light-duty fleet appears suitable for electrification
  - Average daily mileage
  - Suitable EV options to replace LDVs
- ***GPS data needed to verify full range of vehicle operation*** for each application
  - Daily mileage – consistent operation; outlier driving days
  - Driving time vs parked time – vehicle idle operation for "hotel loads"
- **MD/HD initial EV options** available for select vehicle types/vocations to **begin piloting**
  - Need to consider specialty equipment needs of MD/HD vehicles
- Near-term **parallel approach**
  - Deploy commercially available LD EVs and chargers
  - Look for opportunities to demonstrate MD/HD
- Seek **lessons learned** from others
  - Clean Cities – Dallas-Fort Worth Clean Cities and DOE National Clean Cities Network
  - Transit Industry – including DART
  - Other municipal fleets

Next Steps

- Analysis of GPS data to evaluate variability of duty cycles – daily miles distributions, dwell times and locations
- Incorporate replacement criteria to inform priority applications
- Compare vehicle make/model combinations and estimated cost of operation vs. incremental cost
- Evaluate charging infrastructure – priority locations
- Identify near-term EV candidates by fleet based on suitability and replacement criteria
- Quantify fuel / GHG reduction potential

Planned Output

Fleet Inventory

Energy Consumption by Vehicle Type

Identify Priority Vehicles

- Department
- Vehicle Type
- Usage Profile
- EV Availability
- Replacement Criteria
- Parking / Charging Locations

Cost / GHG Impact Estimator

- Vehicle incremental cost
- Incentives
- Energy costs
- Annual Mileage
- Estimated GHG impact

Output Matrix

Listing of Near-Term Candidate EV Replacements

Department
Vehicle ID
Make / Model
Replacement Rank
Annual Mileage
Baseline Energy Consumption
Baseline GHG Production
Replacement Cost
Replacement EV Make / Model
Estimated Energy Consumption
EV Est. Cost
EVSE Est Cost
Est Annual Cost Savings
Est. Annual GHG Savings

Questions or Comments?

Appendix Slides:

- Additional Department Sankey Diagrams by fuel and vehicle counts
- Inventory Distributions by Fleet and Vehicle Type
- Annual Consumption Distributions by Fleet and Vehicle Type
- GPS Data Availability
- Additional Details on Code Compliance Fleet

Scope of NREL Mission

Energy Efficiency

- Residential Buildings
- Commercial Buildings
- Personal and Commercial Vehicles

Renewable Energy

- Solar
- Wind and Water
- Biomass
- Hydrogen
- Geothermal

Systems Integration

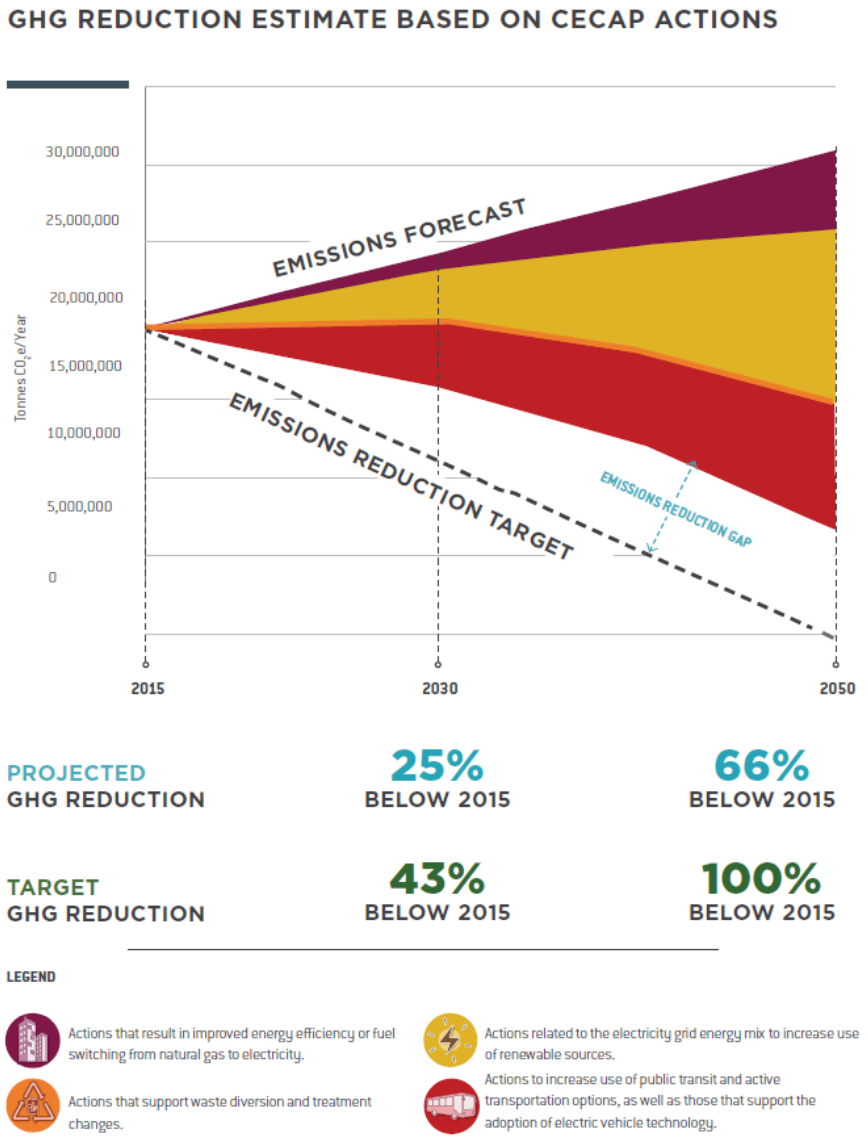
- Grid Infrastructure
- Distributed Energy Interconnection
- Battery and Thermal Storage
- Transportation

Market Focus

- Private Industry
- Federal Agencies
- Defense Dept.
- State/Local Govt.
- International

Dallas Fleet Electrification Goals

- Projected GHG emissions reduction:
  - 25% by 2030
  - 66% by 2050
- Target GHG emissions reduction:
  - 43% by 2030
  - 100% by 2050
- Scenario assumptions
  - Passenger vehicles electrified:
    - 14% by 2030
    - 50% by 2050
  - DART buses electrified:
    - 75% by 2030
    - 100% by 2050
  - ***GHG reductions from federal vehicle fuel efficiency standards:***
    - 2,603,600 MT CO2e/year for 2030
    - 1,536,200 MT CO2e/year for 2050



Dallas Fleet Electrification Goals

- The CECAP comprises 97 actions across eight sectors/goals
  - 45 actions are aimed primarily at reducing GHG emissions
  - 19 actions in transportation sector

WHY TRANSPORTATION MATTERS

- The transportation sector contributes 34% of GHG emissions for the City of Dallas, of which 98% is attributed to on-road transportation.
- Dallas County fails to meet federal air quality standards for ground level ozone, which is a direct result of internal combustion engines, especially gasoline and diesel burning engines.
- **Solutions are aimed at shifting away from single-occupancy commuting, encouraging public transportation, improving vehicle efficiency, and increasing the overall share of electric vehicles.**

WHY AIR QUALITY MATTERS

- Ten counties including Dallas consistently do not meet the 2008 Federal air quality criteria for ground-level ozone.
- Nine counties consistently do not meet the updated 2015 federal standard for ground-level ozone.
- **Reducing pollutants from fossil fuel powered vehicles is likely to have the most impact on poor air quality in Dallas.**

DALLAS' COMMUNITIES HAVE ACCESS TO SUSTAINABLE, AFFORDABLE TRANSPORTATION OPTIONS.

Shift the surface transportation system to move people and goods in fuel-efficient vehicles.

Reduce trips where people drive alone.

Synergize jobs and housing with transportation infrastructure to increase access to walking and biking options, and public transit.

Ensure that walking, biking, public transit, vehicular transportation infrastructure is reliable and safe under all weather conditions.

ALL DALLAS' COMMUNITIES BREATHE CLEAN AIR.

Take a comprehensive approach to addressing air quality at the neighborhood level.

Increase energy efficiency of existing buildings or facilities.

Reduce trips where people drive alone.

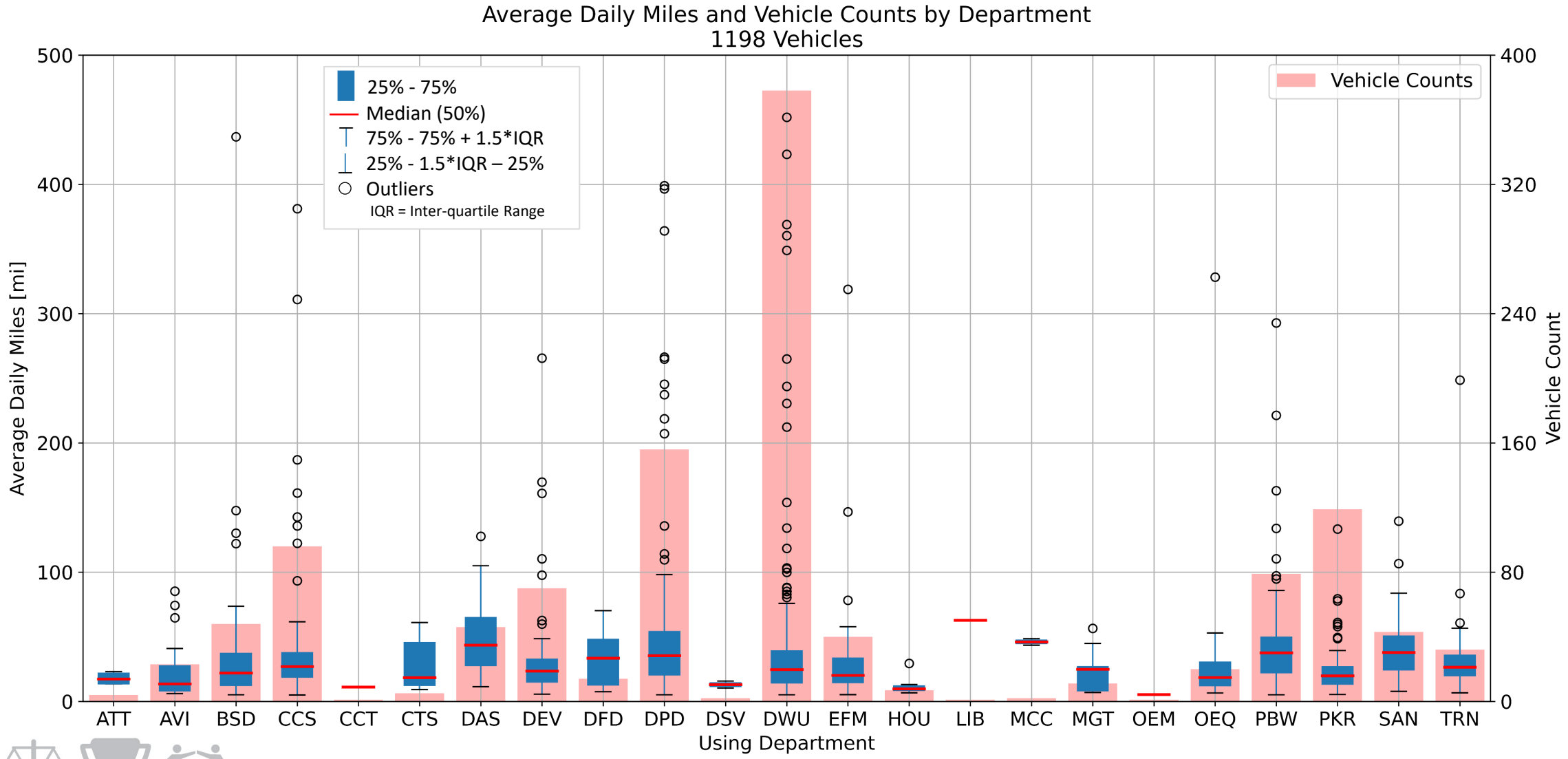
Synergize jobs and housing with transportation infrastructure to increase access to walking and biking options, and public transit.

Increase, enhance and maintain healthy forests, parks, and green spaces, that improve air quality.

Operate a clean, green and efficient waste system.

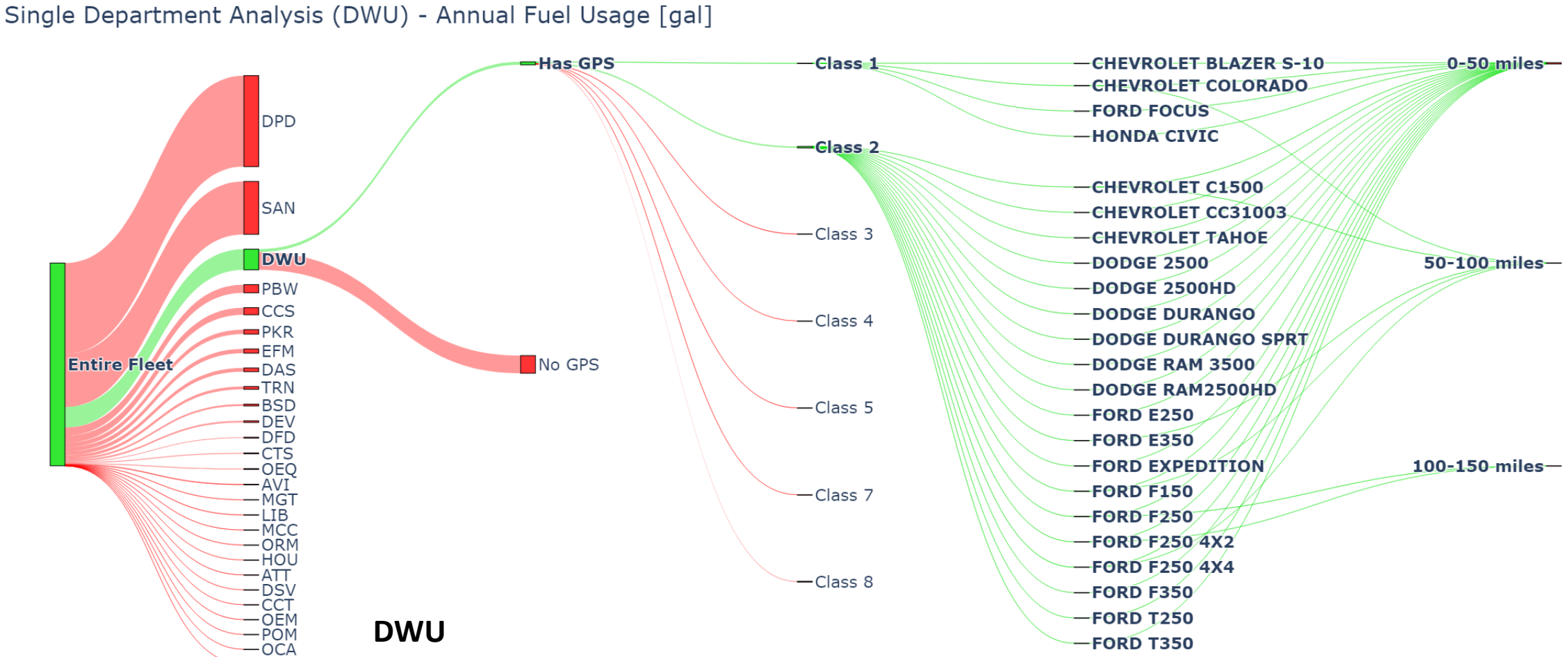
Daily Miles and Vehicle Counts by Department

Class 2



Dallas Vehicle Inventory - Sankey Diagram

Example Process by Annual Fuel Consumption



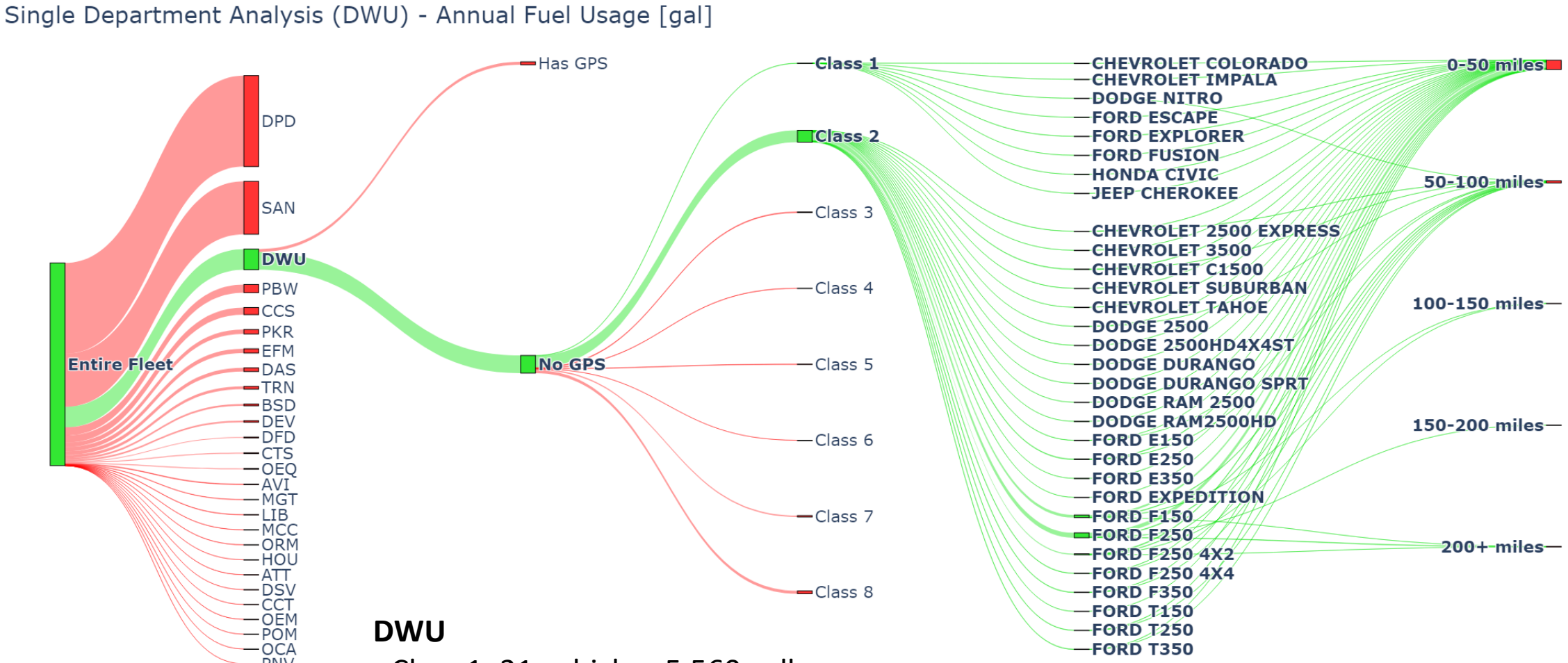
DWU

- Class 1: 6 vehicles, 3,250 gallons
- Class 2: 63 vehicles, 26,600 gallons

Open interactive version in browser

Dallas Vehicle Inventory - Sankey Diagram

Example Process by Annual Fuel Consumption

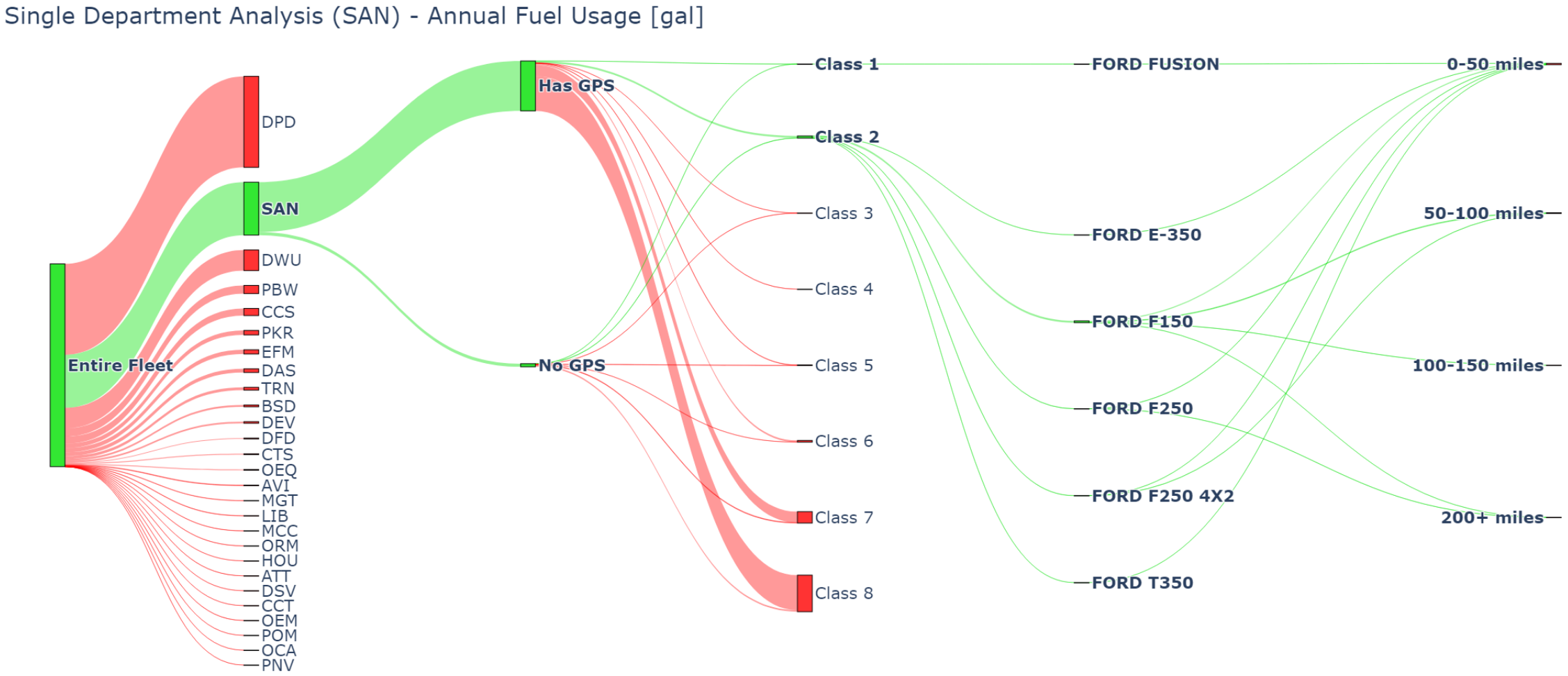


DWU

- Class 1: 21 vehicles, 5,560 gallons
- Class 2: 358 vehicles, 213,000 gallons

Open interactive version in browser

Dallas Vehicle Inventory - Sankey Diagram



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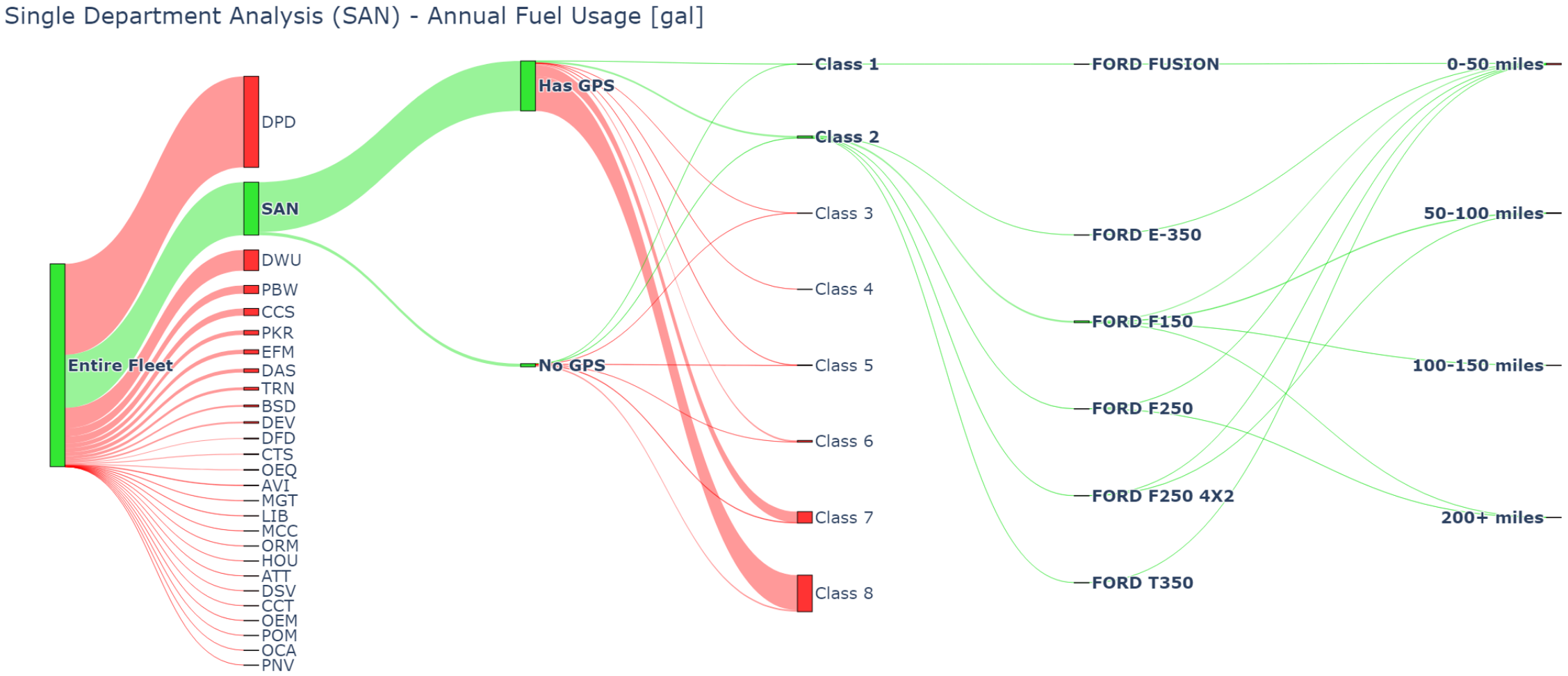

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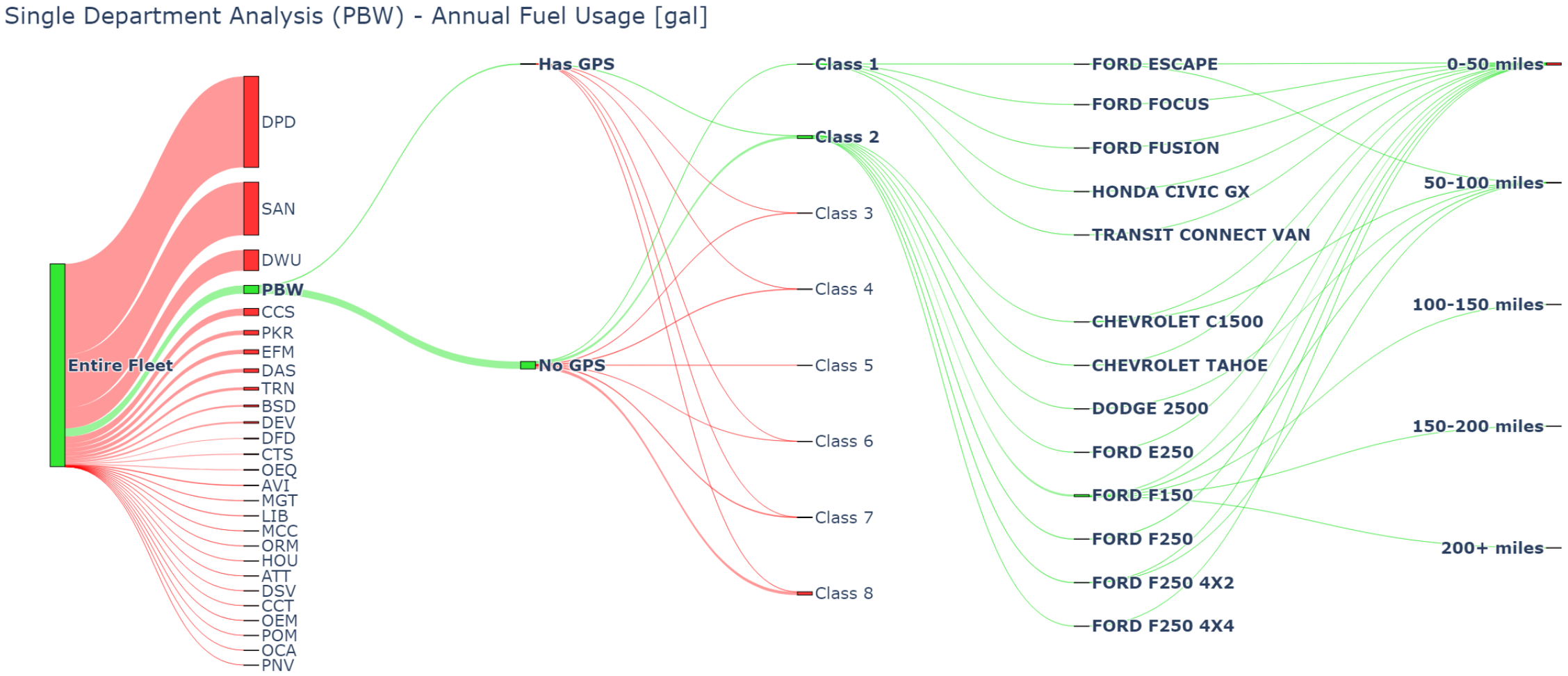

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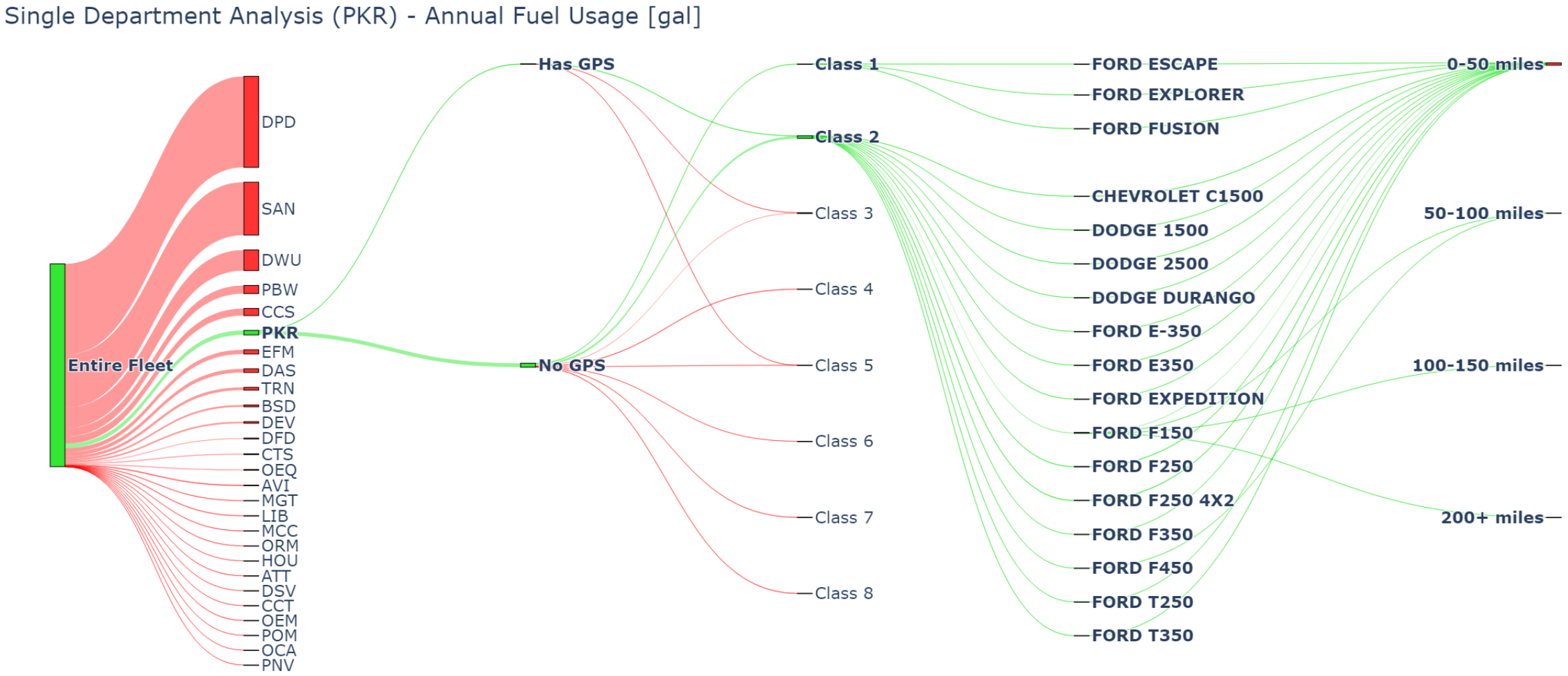

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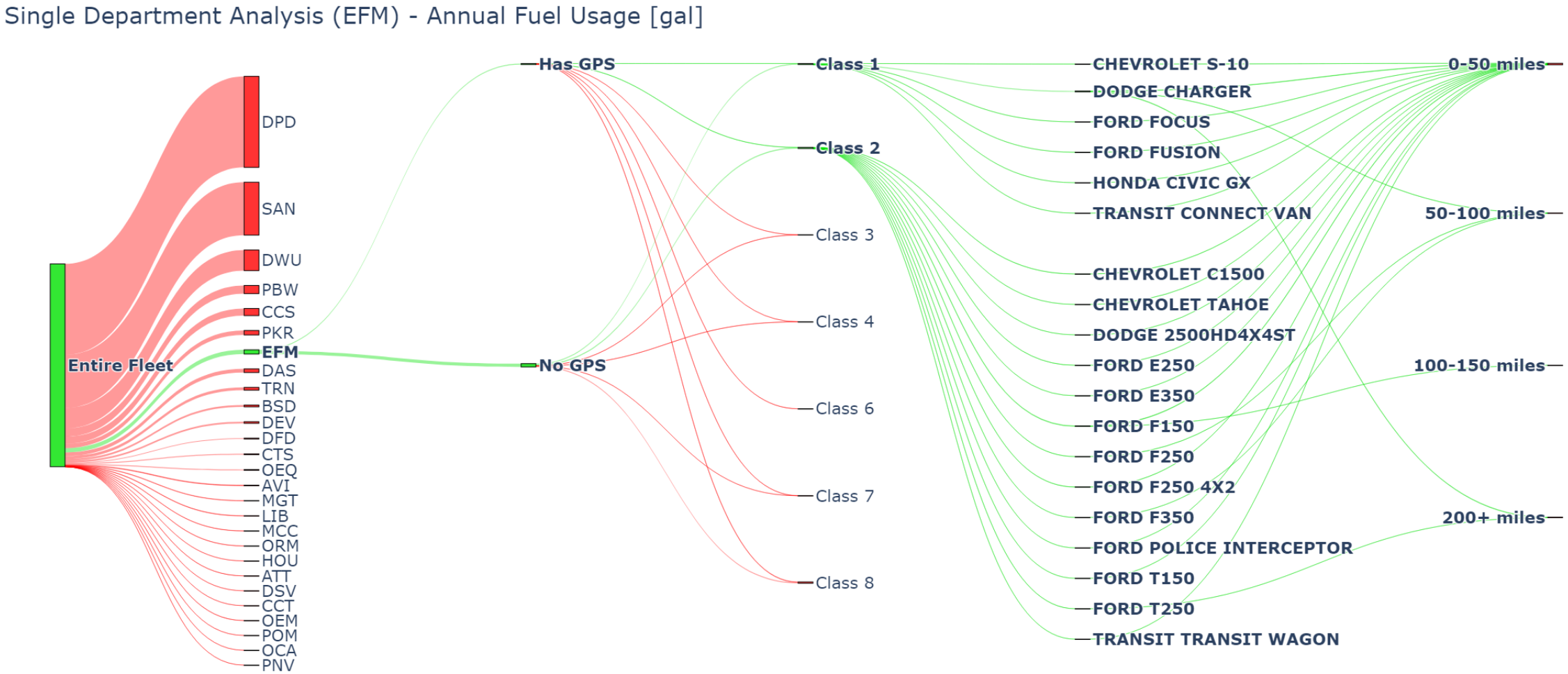

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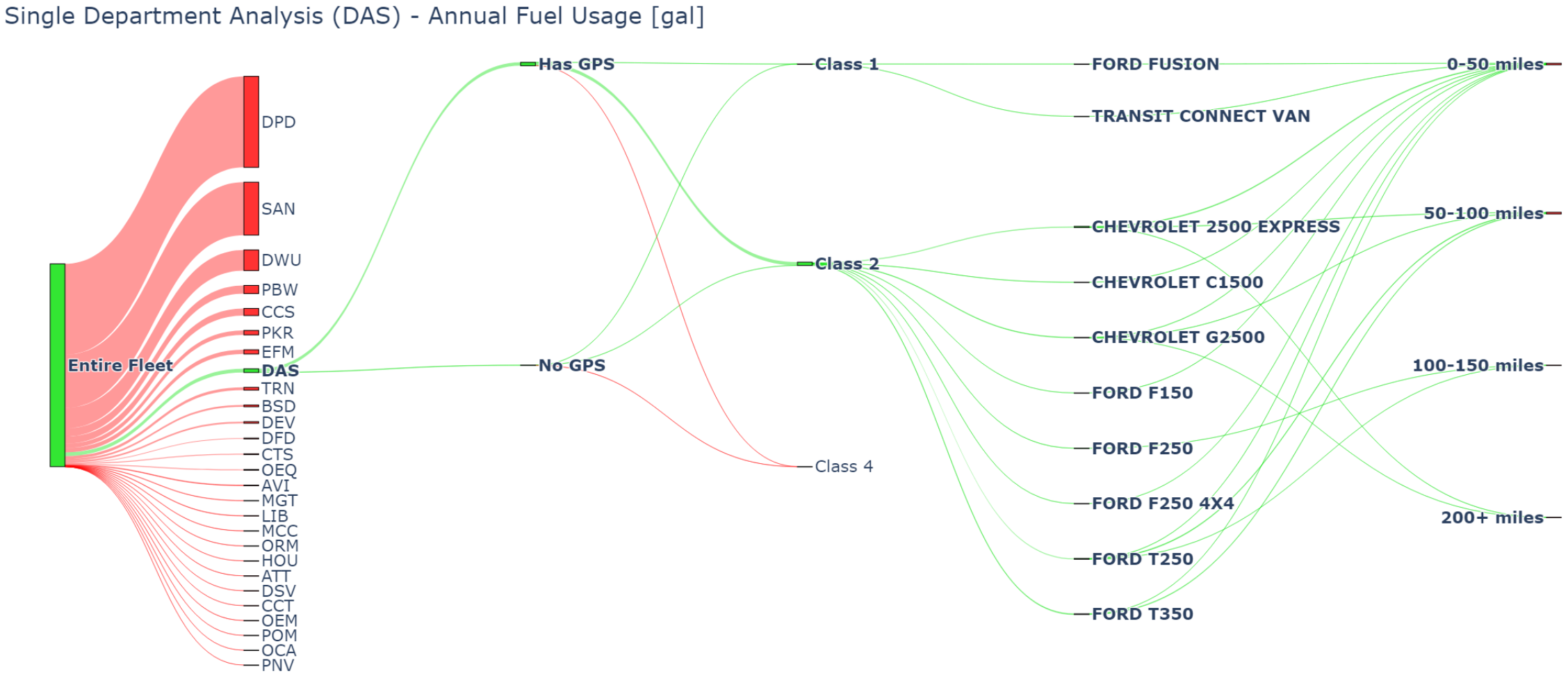

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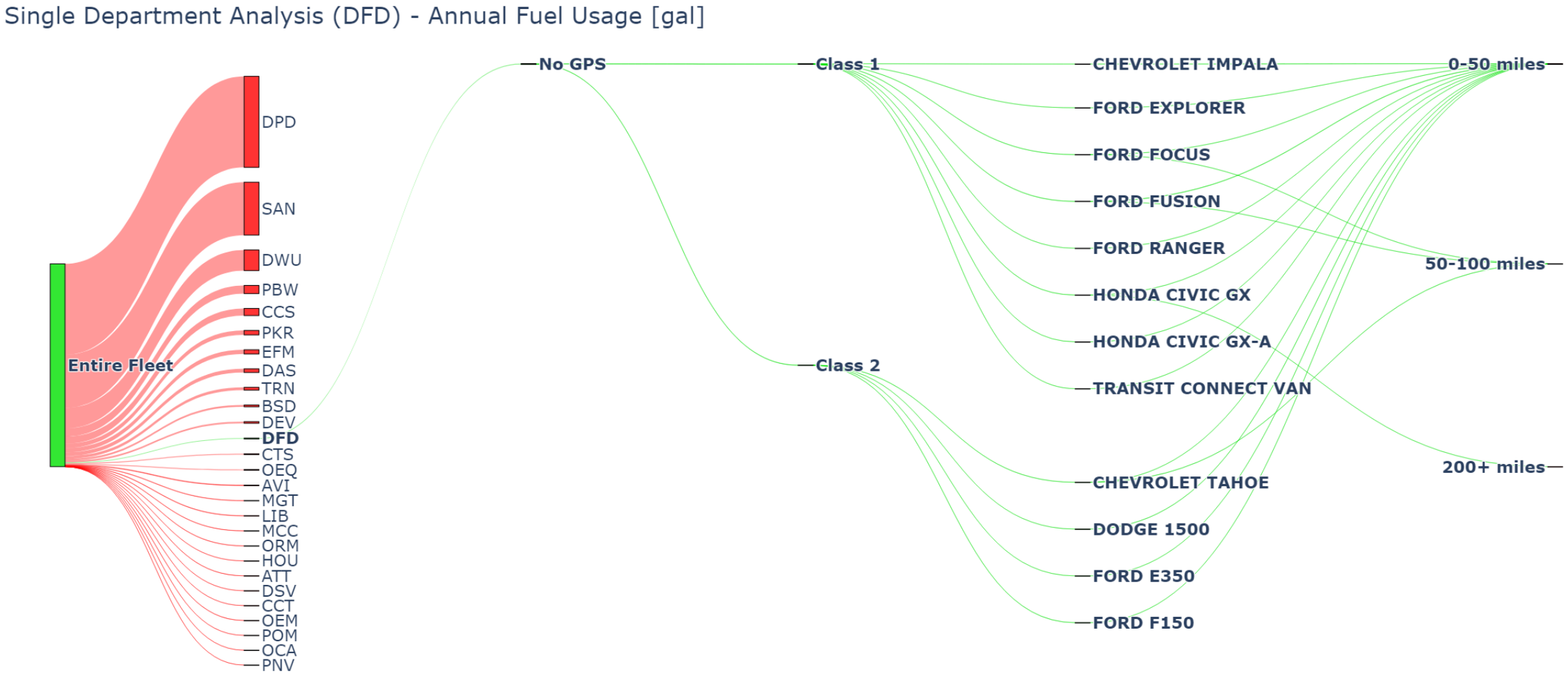
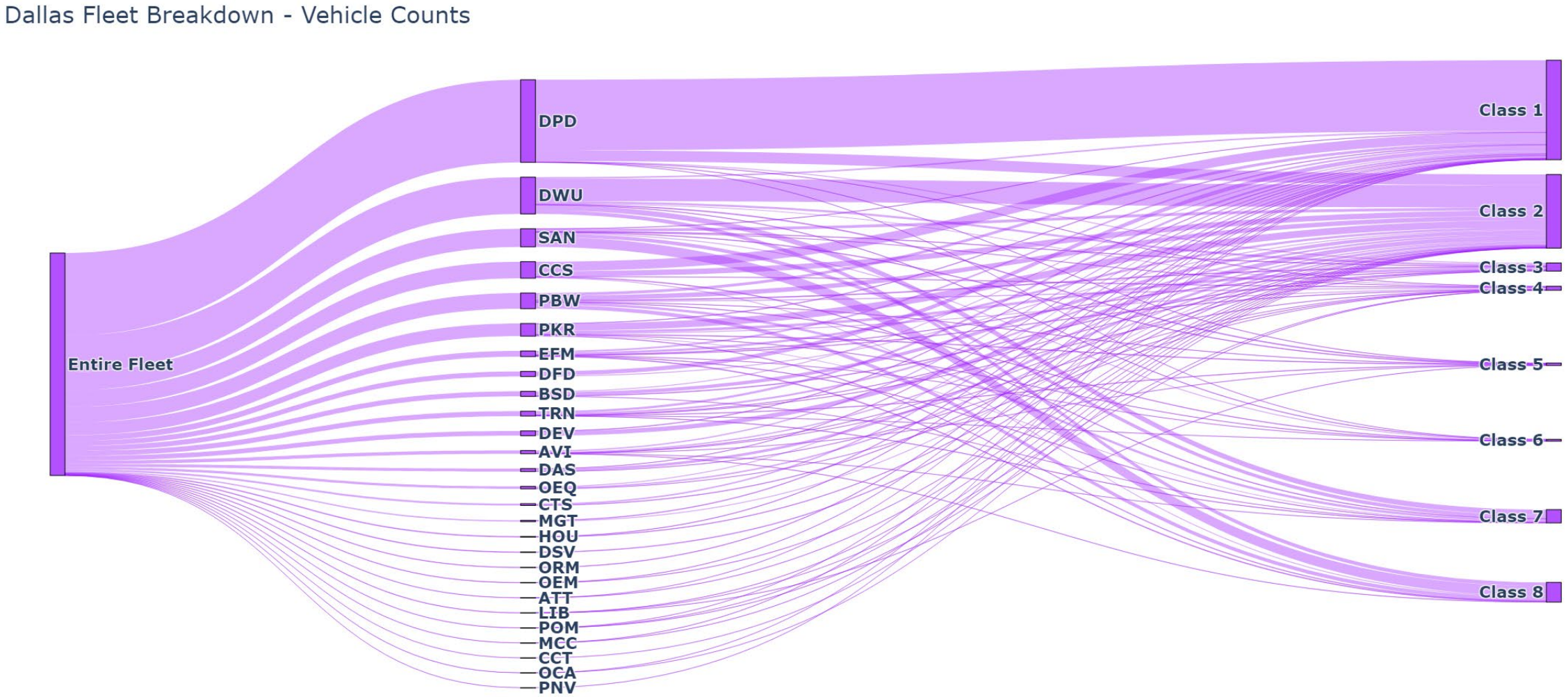


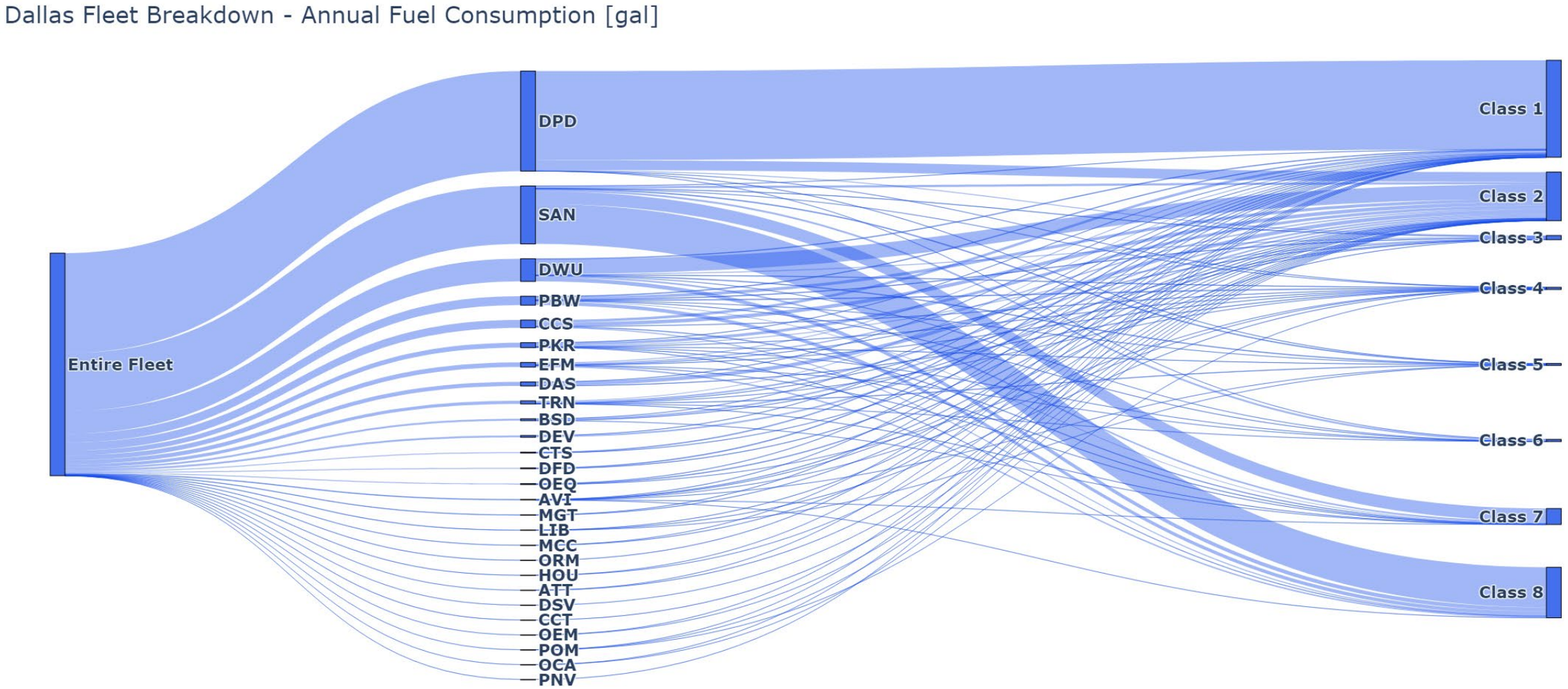
Dallas Vehicle Inventory - Sankey Diagram

Fleet Breakdown by Vehicle Count



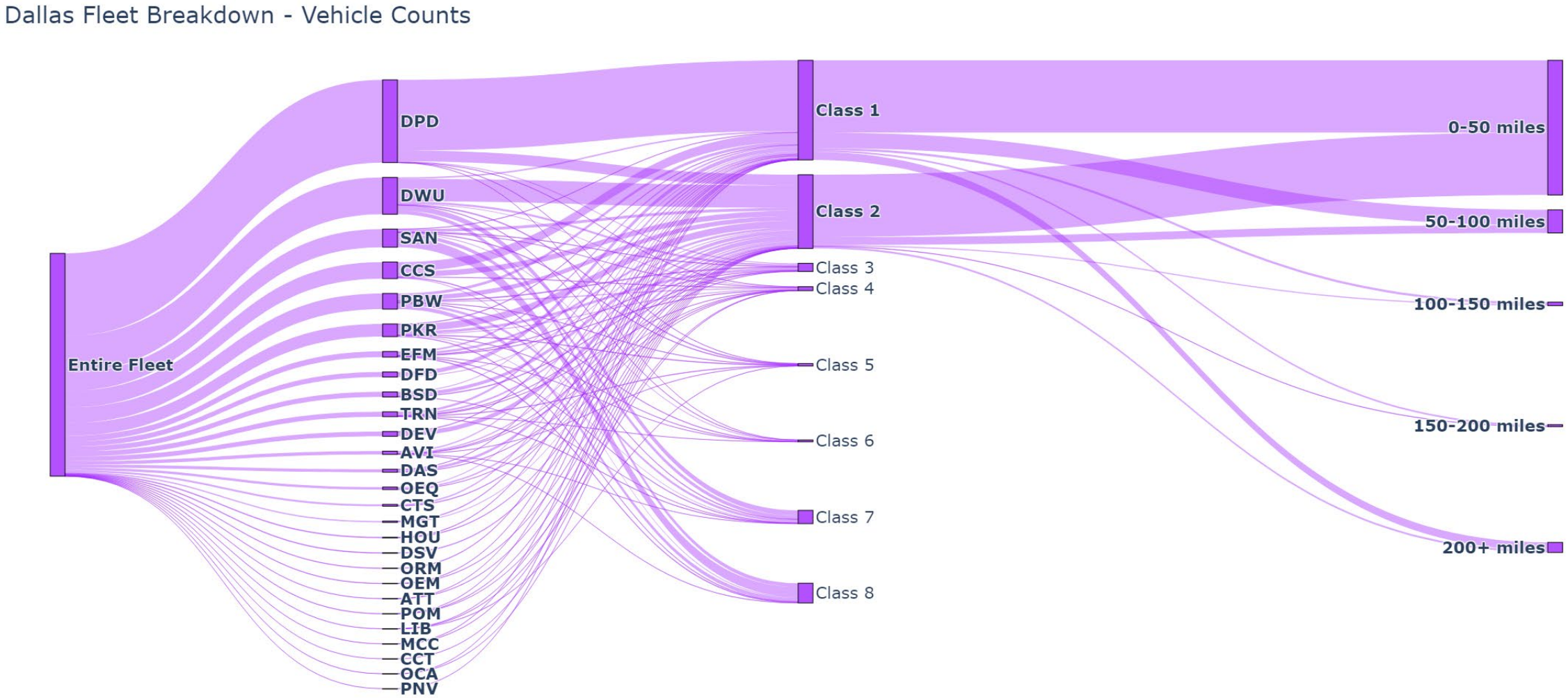
Dallas Vehicle Inventory - Sankey Diagram

Fleet Breakdown by Annual Fuel Consumption



Dallas Vehicle Inventory - Sankey Diagram

Fleet Breakdown by Vehicle Count w/ Miles



Dallas Vehicle Inventory - Sankey Diagram

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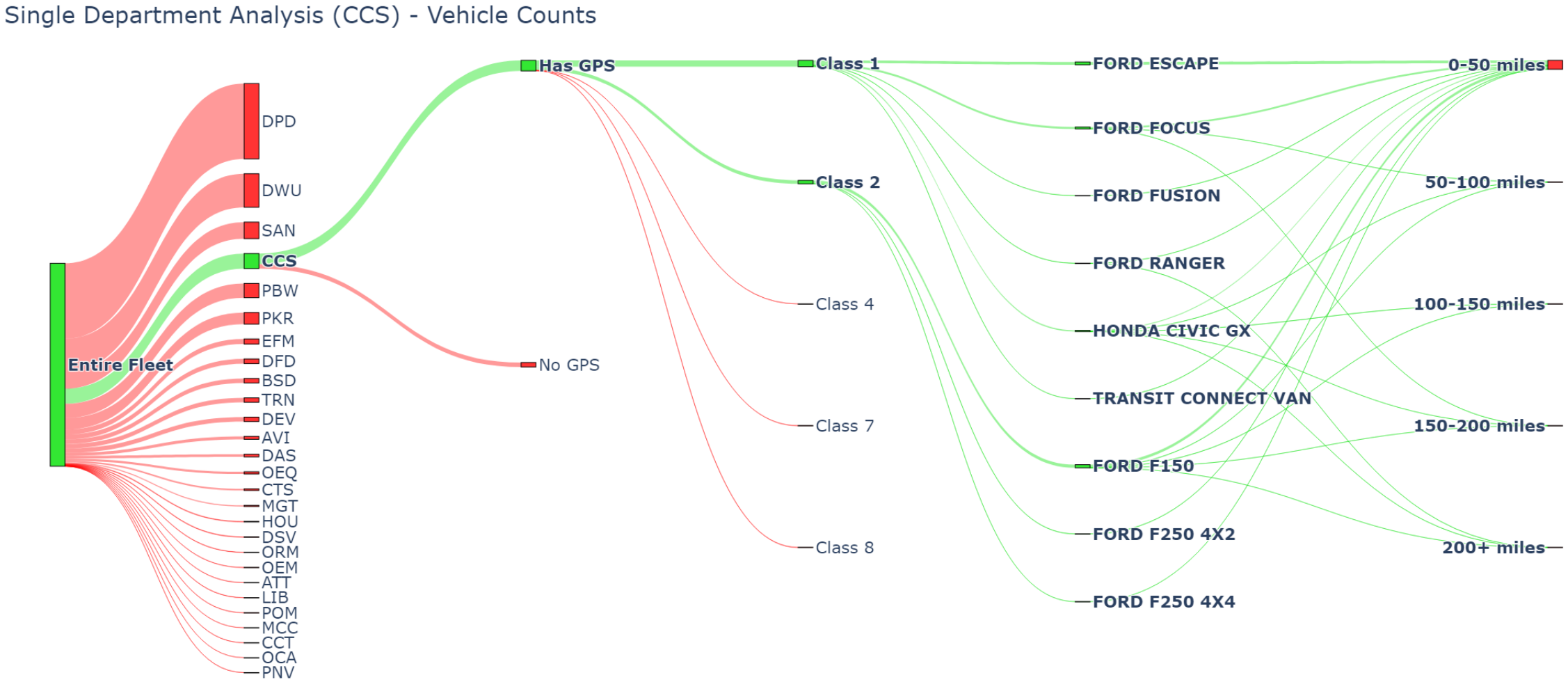
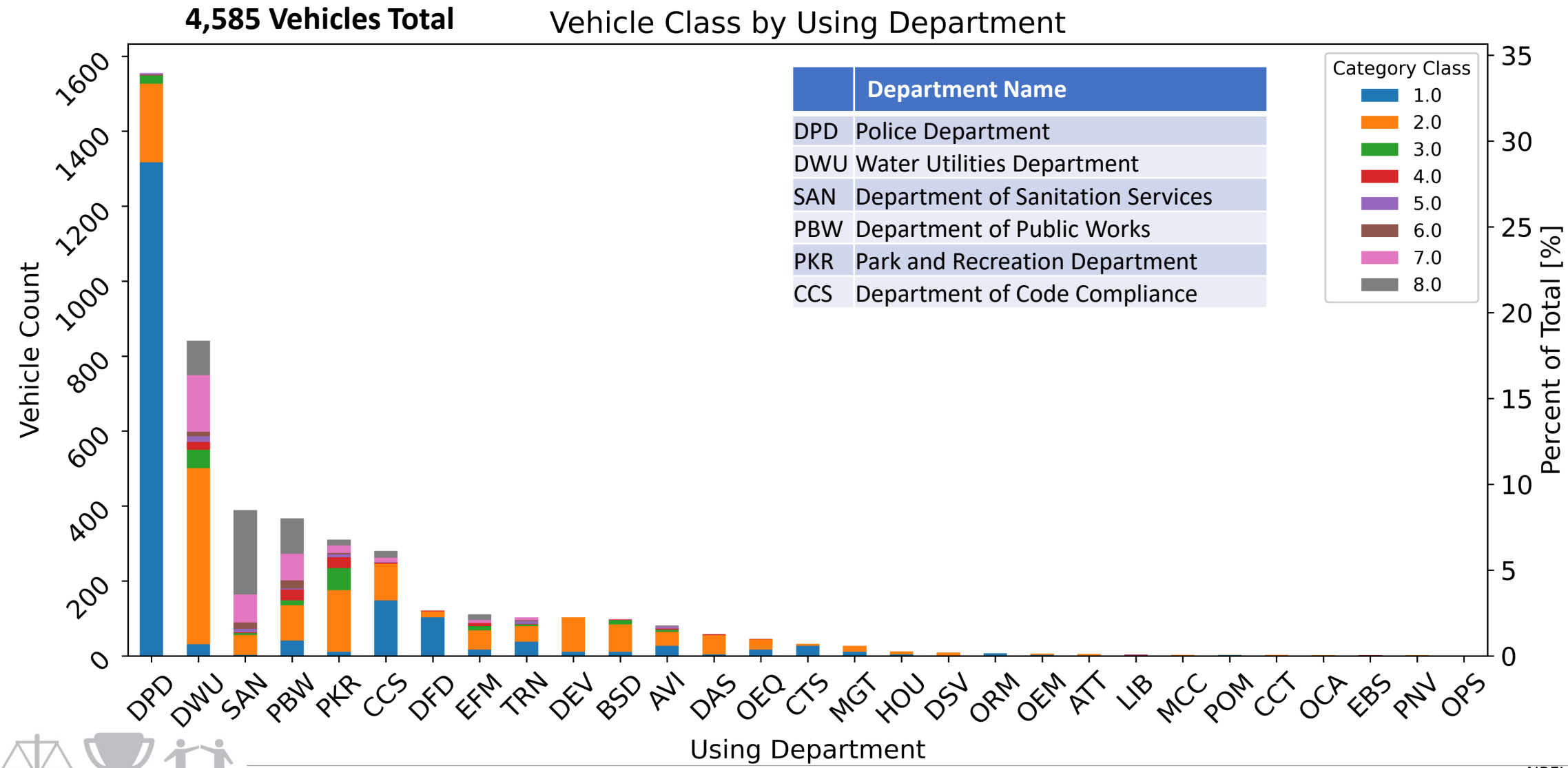
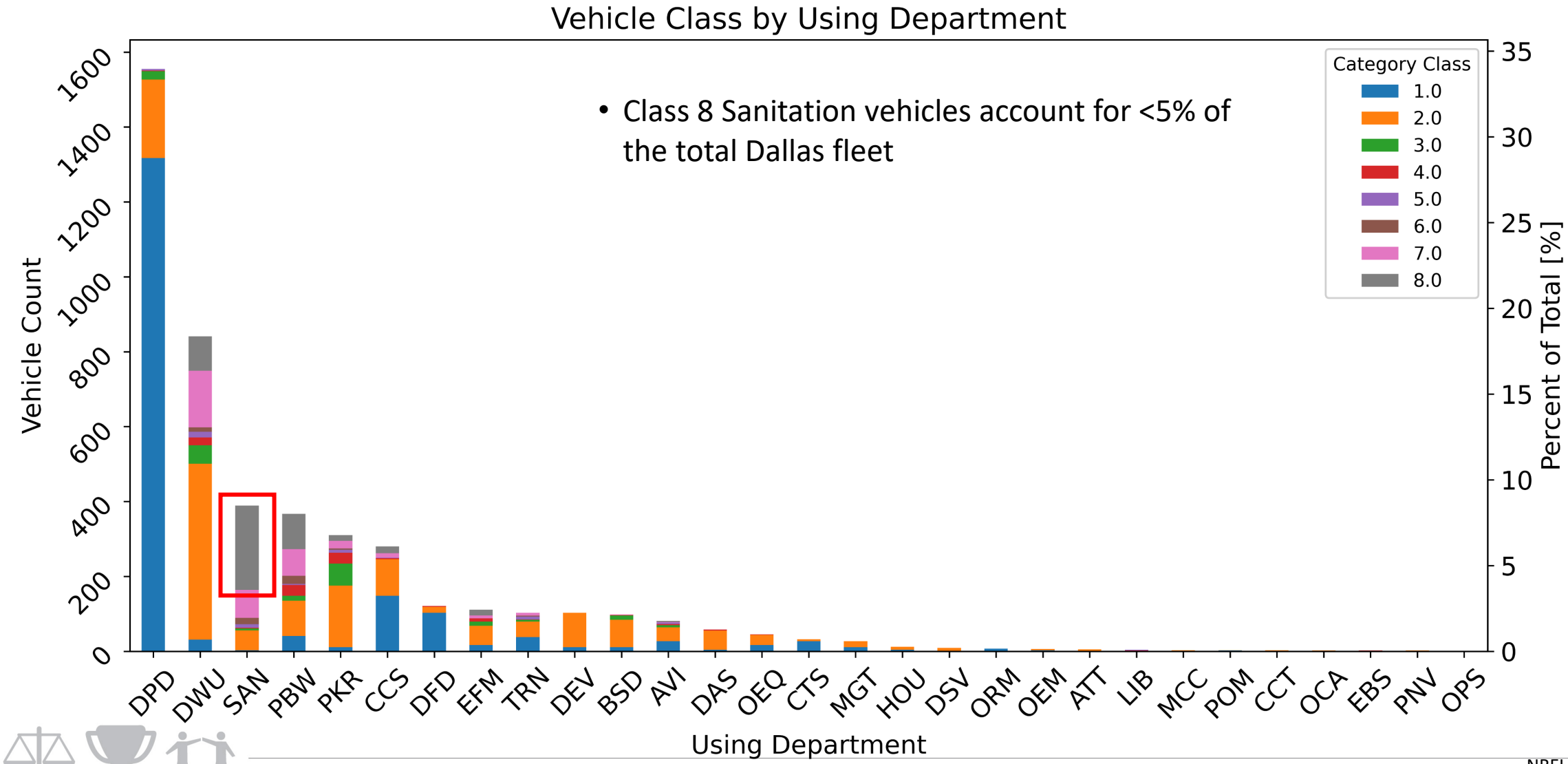


Vehicle Class Distribution by Department



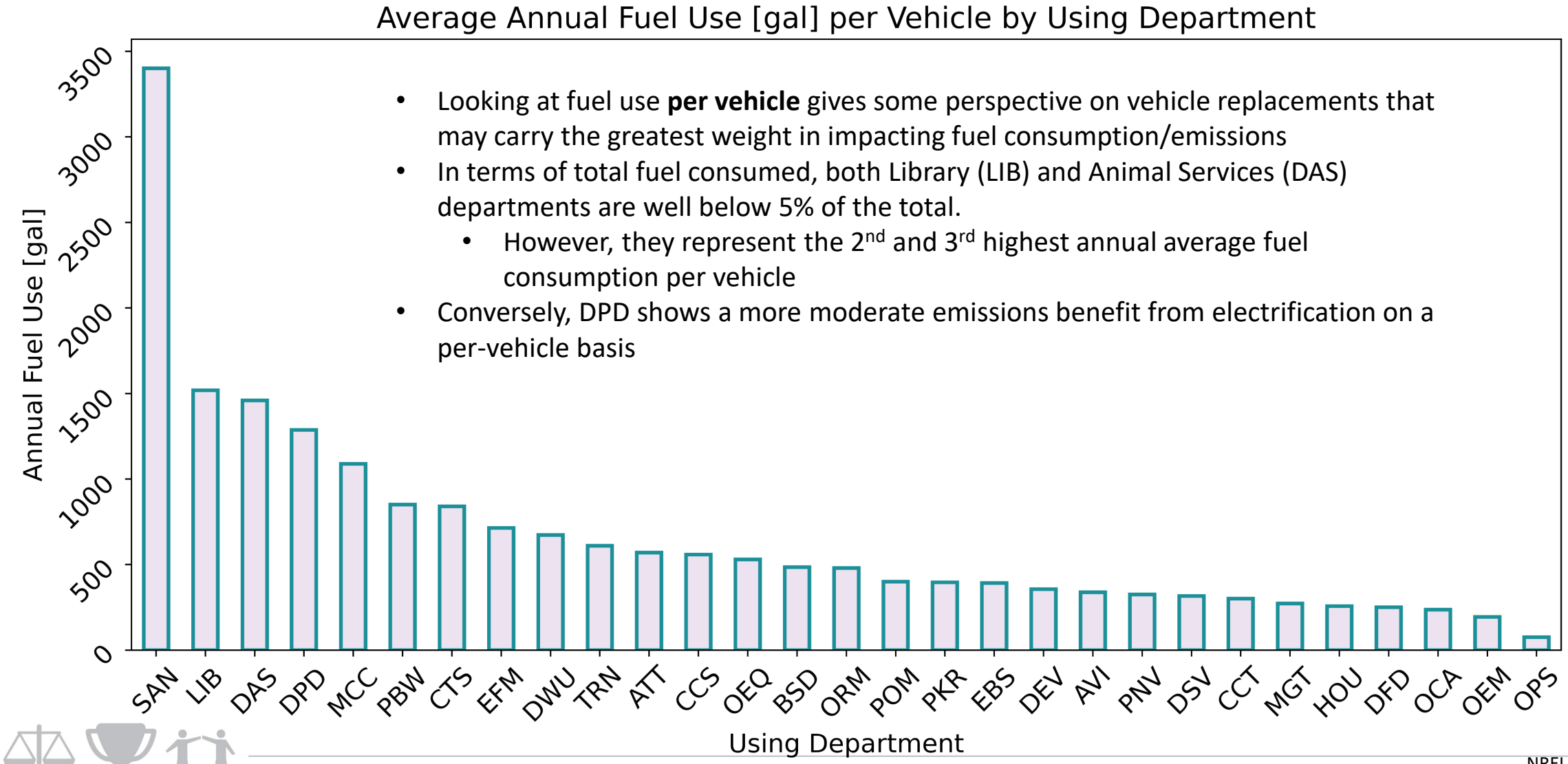
	Department Name
DPD	Police Department
DWU	Water Utilities Department
SAN	Department of Sanitation Services
PBW	Department of Public Works
PKR	Park and Recreation Department
CCS	Department of Code Compliance

Vehicle Class Distribution by Department



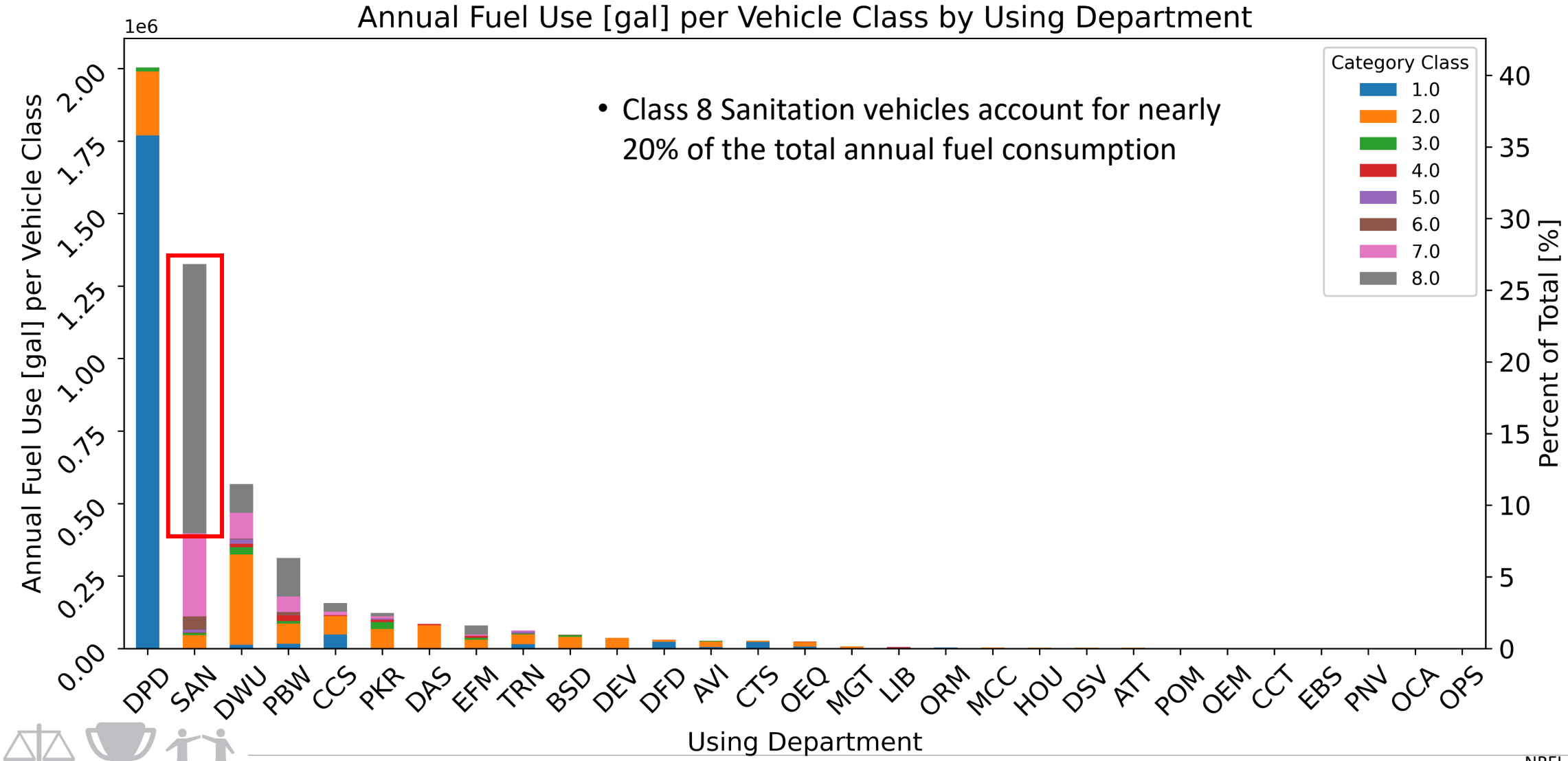
- Class 8 Sanitation vehicles account for <5% of the total Dallas fleet

Annual Fuel Use PER VEHICLE by Dept



- Looking at fuel use **per vehicle** gives some perspective on vehicle replacements that may carry the greatest weight in impacting fuel consumption/emissions
- In terms of total fuel consumed, both Library (LIB) and Animal Services (DAS) departments are well below 5% of the total.
  - However, they represent the 2nd and 3rd highest annual average fuel consumption per vehicle
- Conversely, DPD shows a more moderate emissions benefit from electrification on a per-vehicle basis

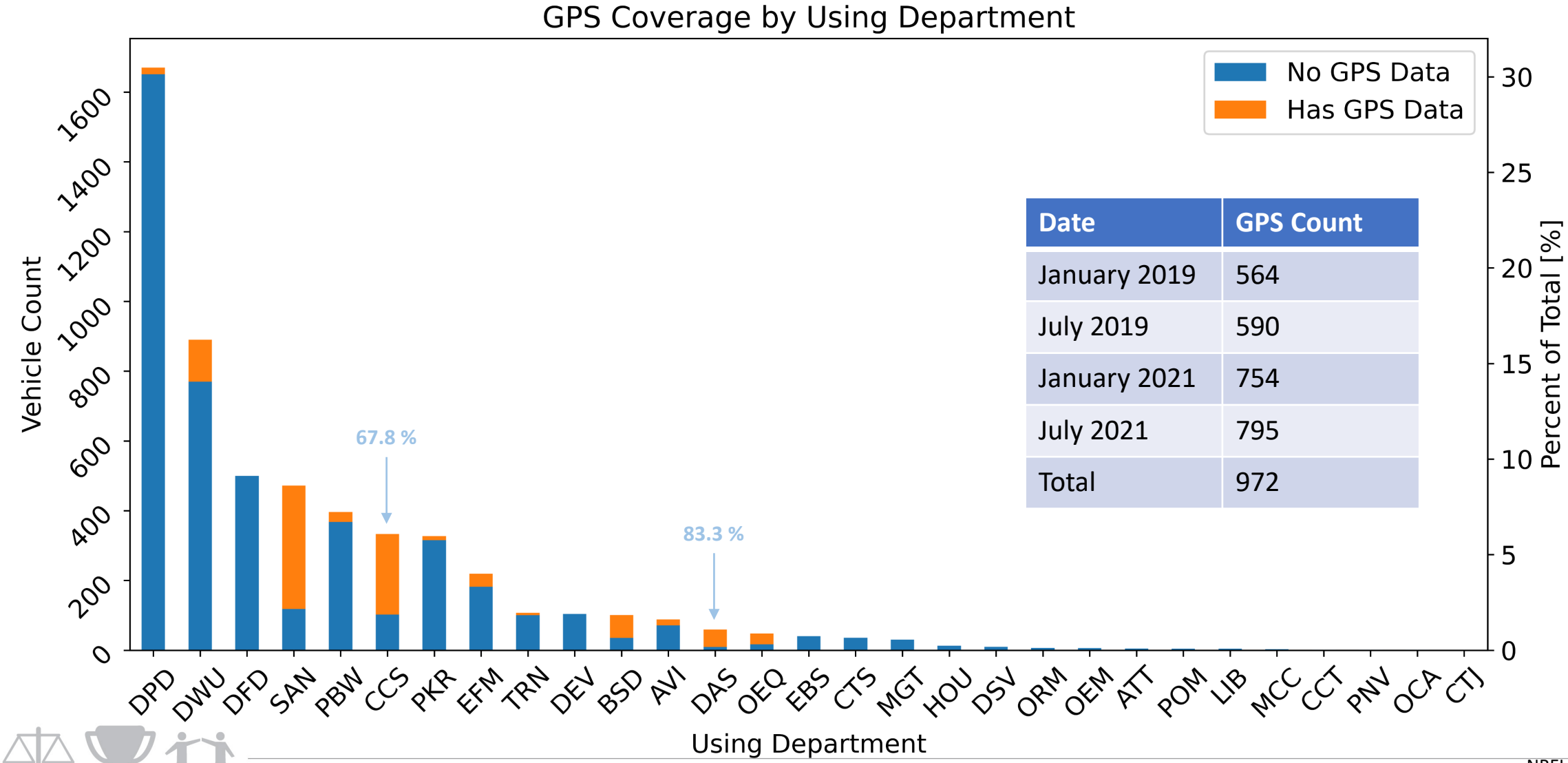
Annual Fuel Use per Vehicle Class by Dept



GPS Data Review

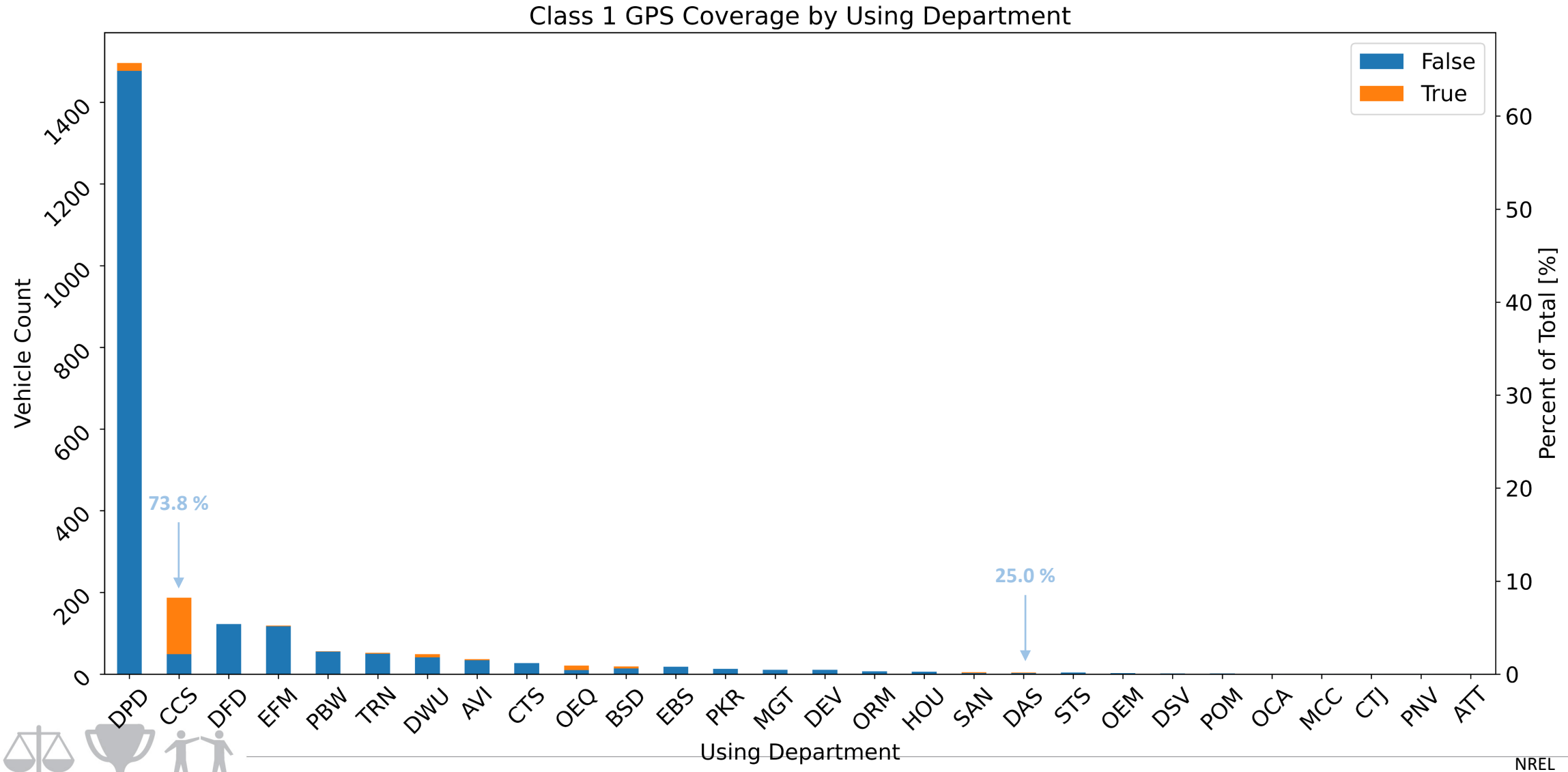
- The vehicle inventory can only provide estimates of daily operation and fuel consumption by vehicle
  - Estimates based on annual totals and assumptions for operating days
- GPS data can provide a more accurate view of vehicle operation
  - Vehicle schedule, operating days of the week
  - Range/variability of daily distance traveled
  - Percent of vehicle idle operation to indicate higher use of “hotel loads”
  - Stops/dwell periods and locations

CalAmp GPS Data

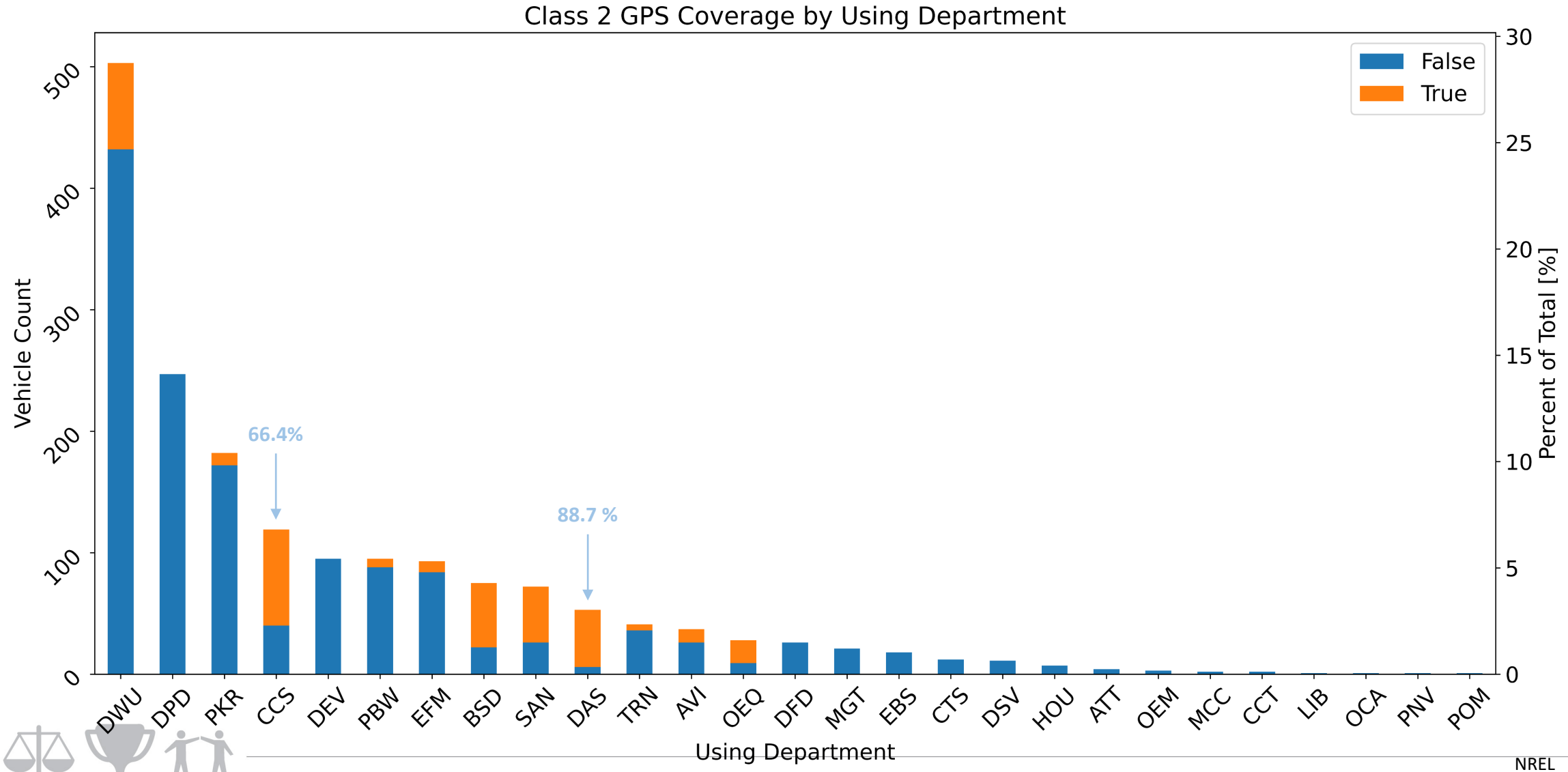


Date	GPS Count
January 2019	564
July 2019	590
January 2021	754
July 2021	795
Total	972

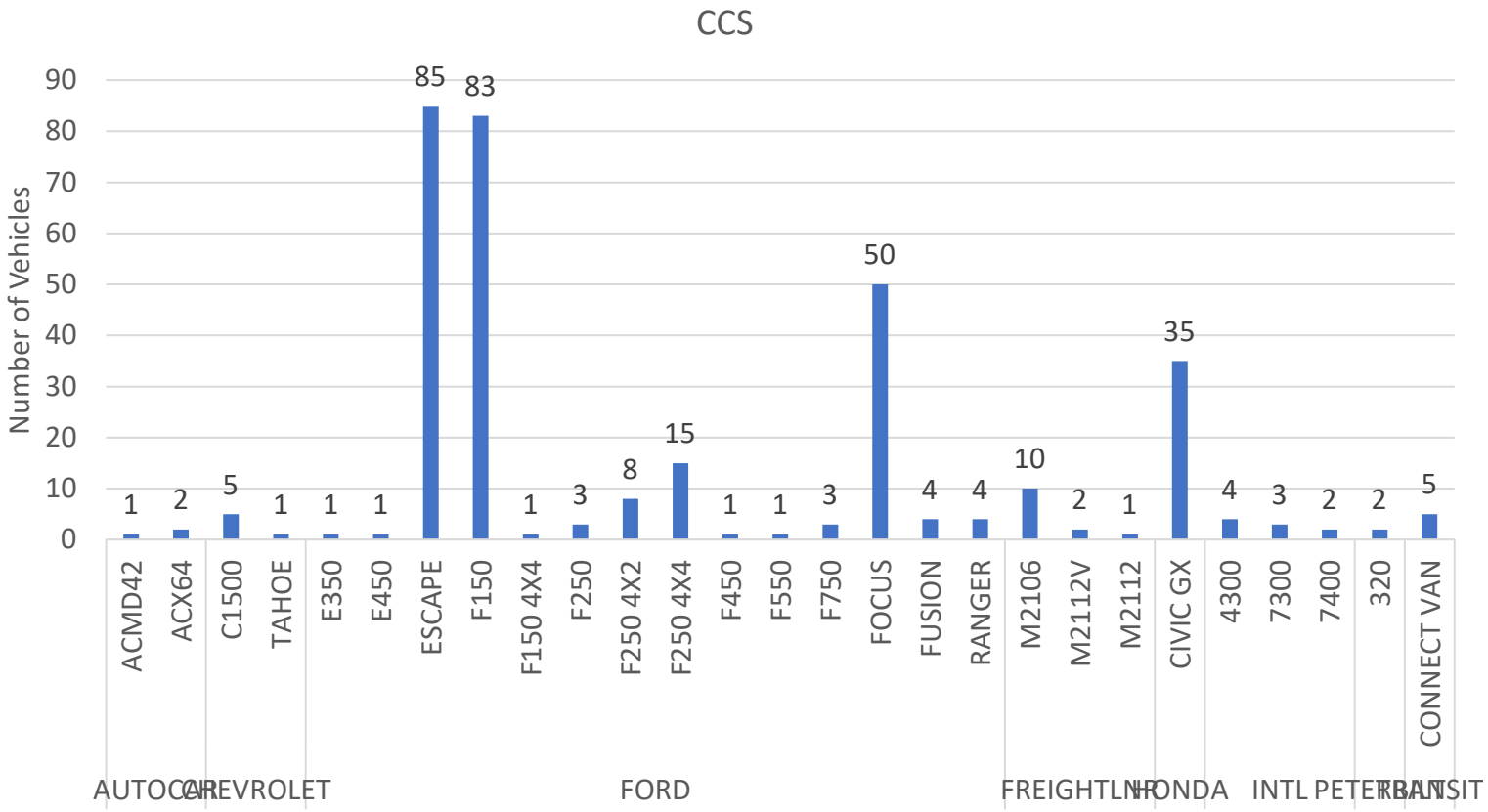
CalAmp GPS Data



CalAmp GPS Data



CCS Fleet Composition



CCS - Current Fleet

Ford Escape = 85

Ford F150 = 83

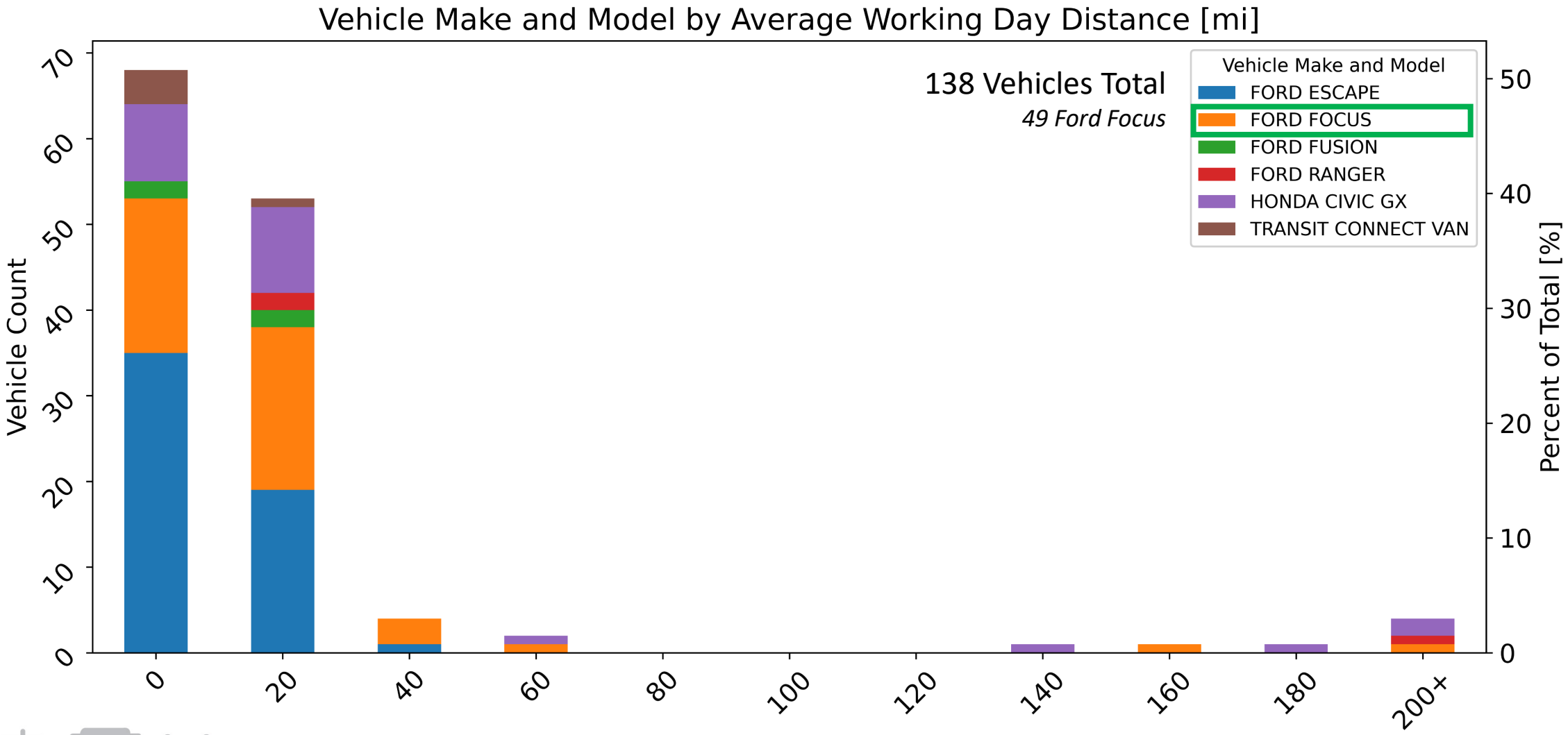
Ford Focus = 50

Honda Civic = 35

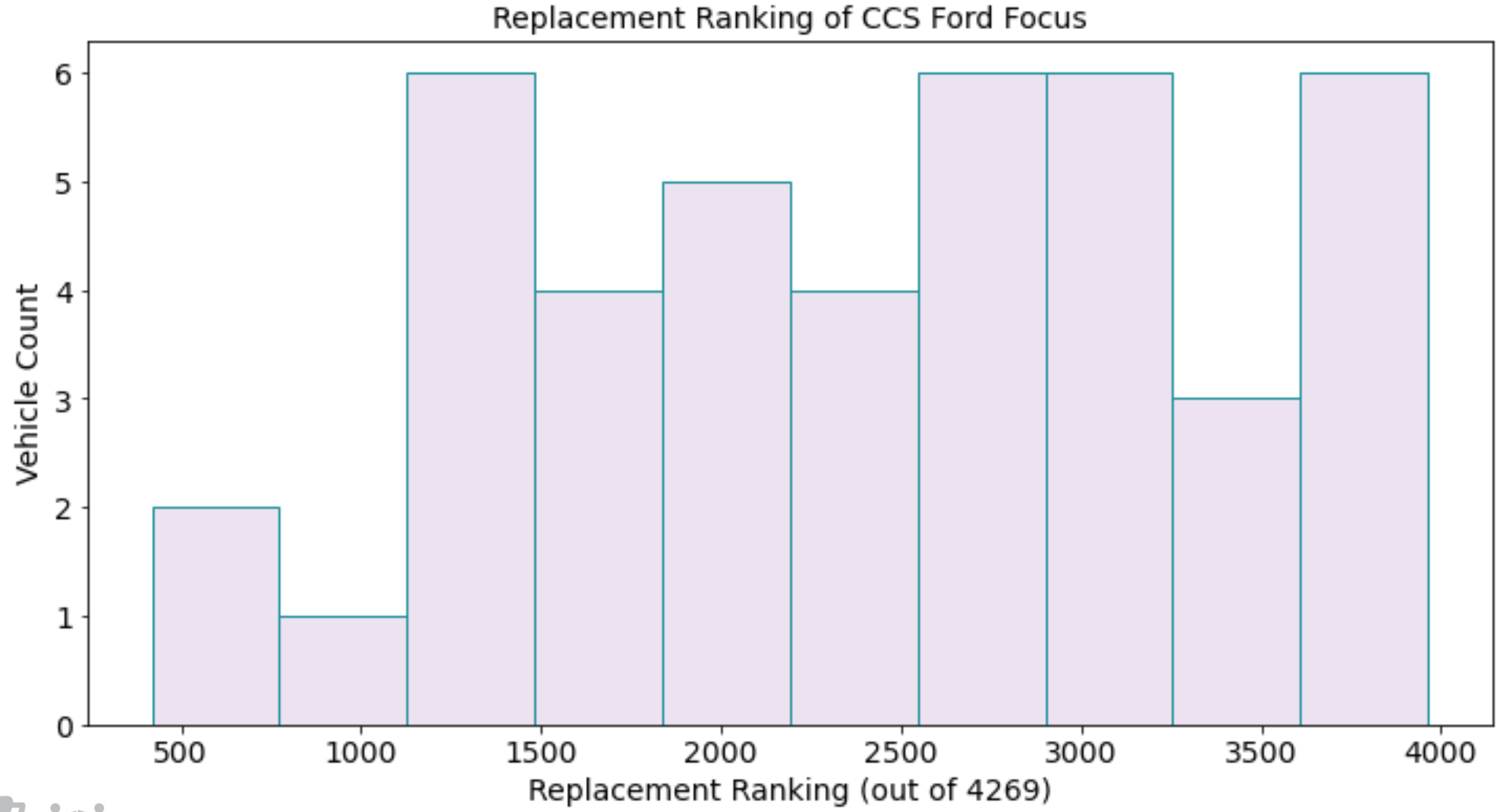
Transit Connect Van = 5

Make and Model Counts by Daily Distance

CCS - Class 1

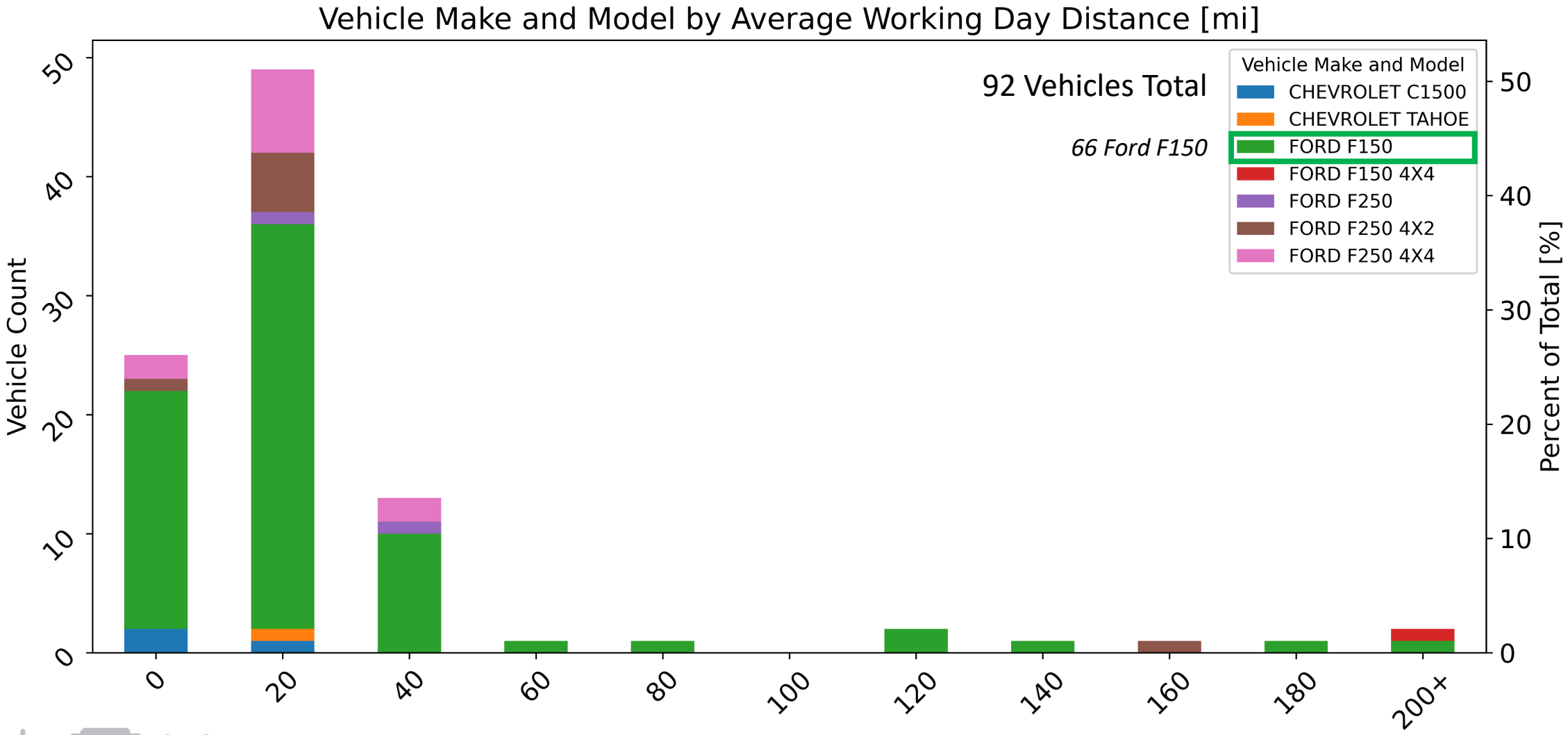


Replacement Ranking of CCS Ford Focus

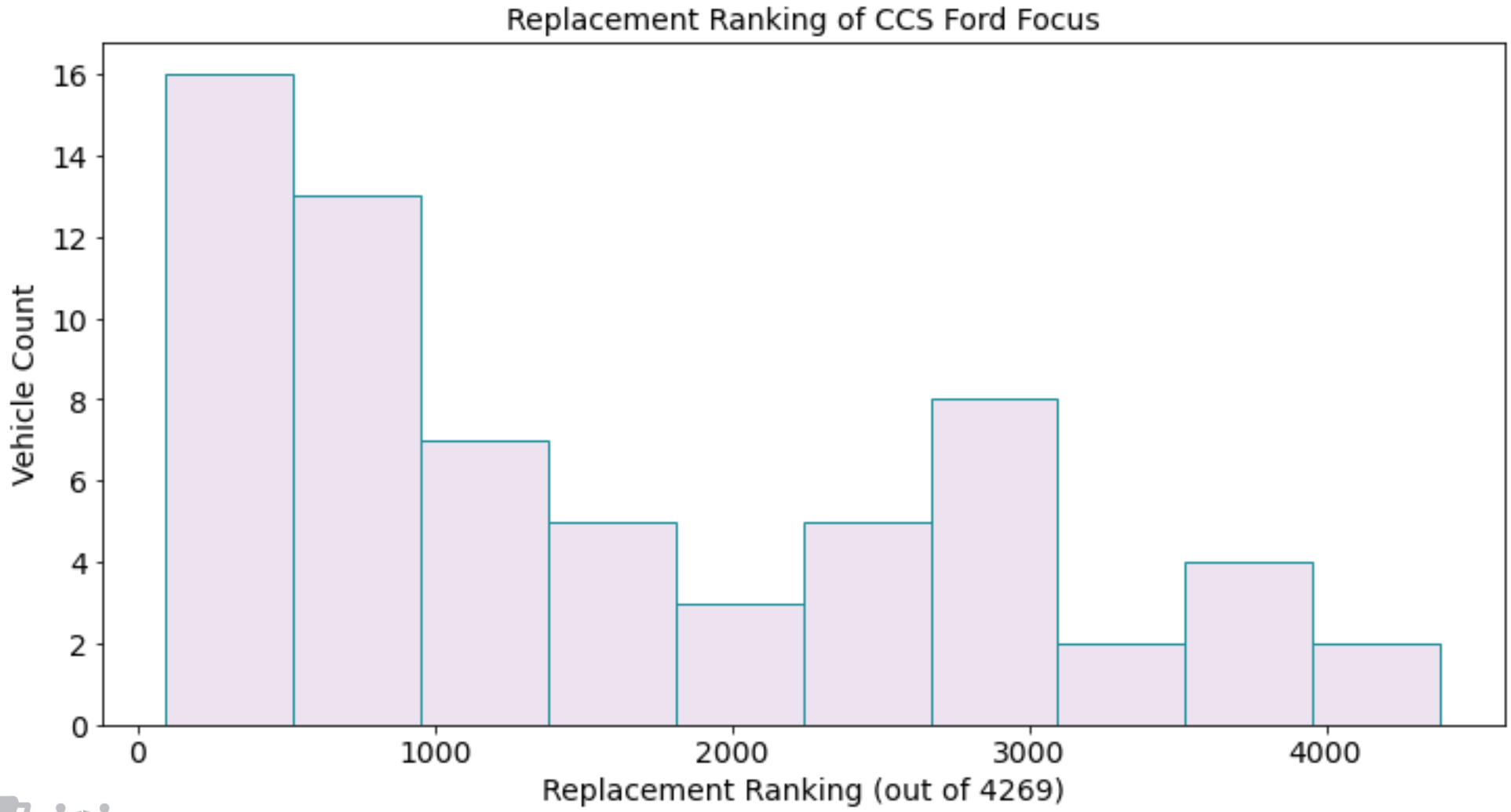


Make and Model Counts by Daily Distance

CCS - Class 2



Replacement Ranking of CCS Ford F150



Vehicle Capital Costs

- Sample of MSRP values for class 1 EV examples
  - *To be compared to replacement cost values from vehicle inventory*

All-Electric (EV)								
Make	**Model**	**EV Type**	**Base MSRP**	**Federal tax credit**	**Price after federal tax credit**	**Battery size (kWh)**	**Electric Range (miles)**	**Total Range (miles)**
Chevrolet	Bolt EV	BEV	$31,000	$0	$31,000	66	259	259
Chevrolet	Bolt EUV	BEV	$33,000	$0	$33,000	66	247	247
Ford	Mustang Mach-E	BEV	$42,895	$7,500	$35,395	76-99	210-300	210-300
Hyundai	Ioniq EV	BEV	$33,045	$7,500	$25,545	38	170	170
Kia	Niro EV	BEV	$39,990	$7,500	$32,490	64	239	239
Mini	Cooper SE	BEV	$29,900	$7,500	$22,400	33	114	114
Nissan	Leaf	BEV	$27,400	$7,500	$19,900	40-62	150-226	150-226
Tesla	Model 3	BEV	$39,990	$0	$39,990	60-75	263-353	263-353
Audi	e-tron	BEV	$65,900	$7,500	$58,400	95	222	222
Audi	e-tron Sportback	BEV	$69,100	$7,500	$61,600	95	218	218
Hyundai	Kona EV	BEV	$37,190	$7,500	$29,690	64	258	258
Volkswagen	ID4	BEV	$39,995	$7,500	$32,495	78	240-260	240-260
Volvo	XC40 Recharge	BEV	$53,990	$7,500	$46,490	78	223	223

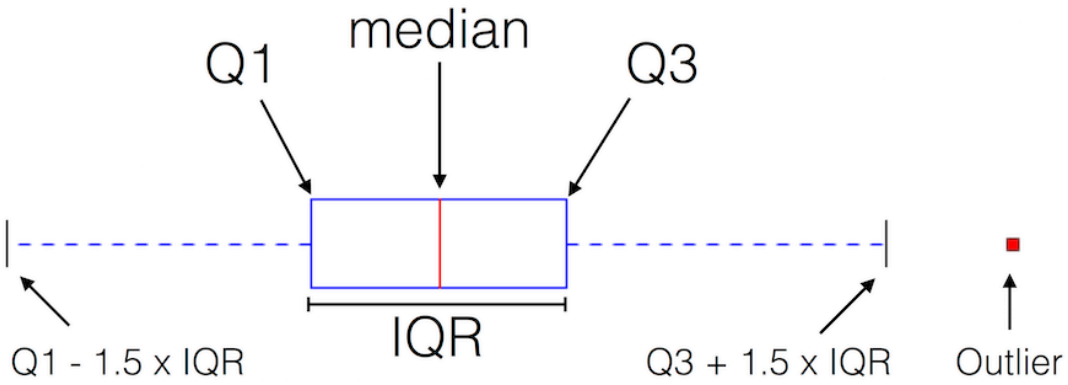
https://www.shift2electric.com/evinfolist

Department Names

Acronym	Department Name
ATT	City Attorney's Office
AVI	Department of Aviation
BSD	Building Services Department
CCS	Department of Code Compliance
CCT	Department of Convention and Event Services
CTS	Court & Detention Services
DAS	Department of Dallas Animal Services
DEV	Department of Development Services
DFD	Fire-Rescue Department
DPD	Police Department
DSV	Department of Information and Technology Services
DWU	Water Utilities Department
EBS	Equipment and Building Services *(split into BSD and EFM)*
EFM	Department of Equipment and Fleet Management

Acronym	Department Name
HOU	Department of Housing & Neighborhood Revitalization
LIB	Library
MCC	Mayor and City Council Office
MGT	Office of Management Services
OCA	Office of Arts and Culture
OEM	Office of Emergency Management
OEQ	Office of Environmental Quality and Sustainability
OPS	Office of Procurement Services *(same as POM)*
ORM	Office of Risk Management
PBW	Department of Public Works
PKR	Park and Recreation Department
PNV	Department of Planning and Urban Design
POM	Office of Procurement Services *(same as OPS)*
SAN	Department of Sanitation Services
TRN	Department of Transportation

Box Plot Reference



Q1: *Quartile 1*, or median of the *left* data subset
after dividing the original data set into 2 subsets via the median
(25% of the data points fall below this threshold)

Q3: *Quartile 3*, median of the *right* data subset
(75% of the data points fall below this threshold)

IQR: *Interquartile-range*, Q3 - Q1

Outliers: Data points are considered to be outliers if
value < *Q1 - 1.5 x IQR* or
value > Q3 + 1.5 x IQR