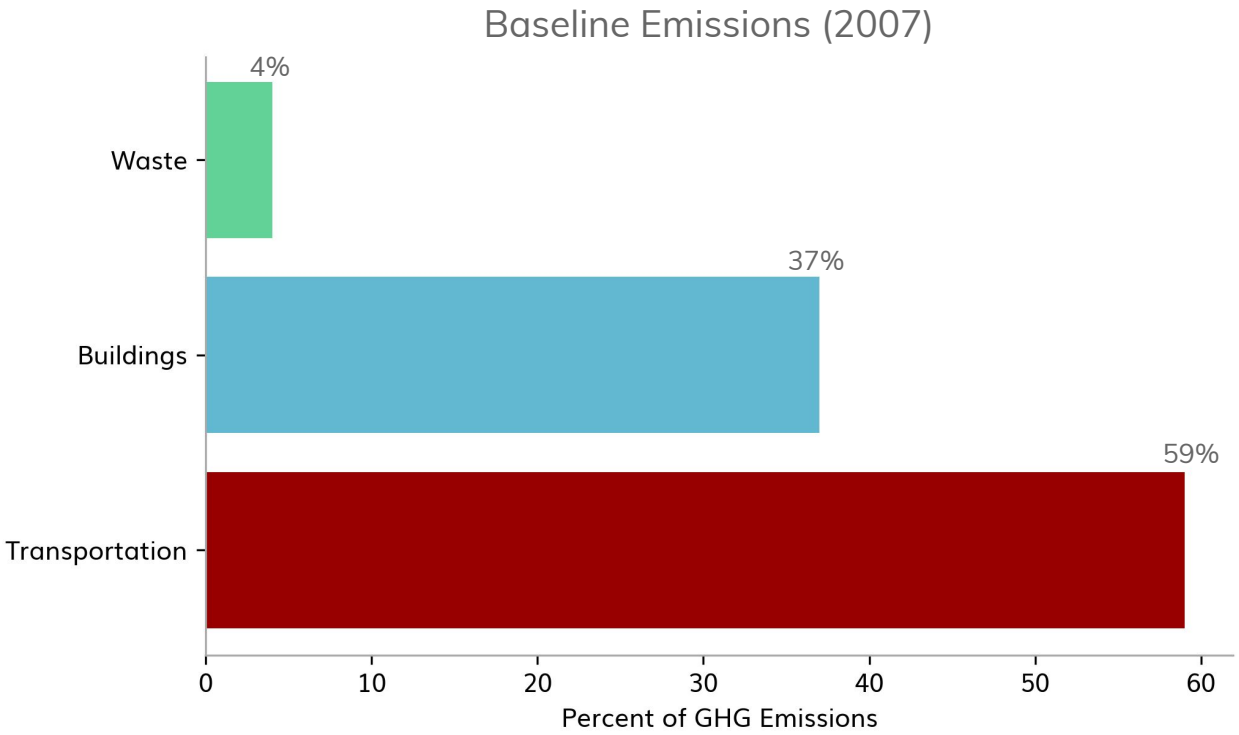
Transportation Vehicle Modelling for Policy Analysis

Presenters: **Andy Hong** and **Kevin Wong**
(Unable to Attend: Nimrah Anwar and Mia Kramer)

Sept 20th, 2018

Transportation Contributes the Majority of GHG Emissions



Source:
City of Surrey
Community & Emissions Plan, 2013:34

Our Planned Deliverables

Vehicle Stock Insights

How has vehicle ownership changed between 2006 and 2016?

What other factors correlate with different vehicle stock composition?

Policy Analysis Tools

If we meet particular targets for vehicle stock composition, how will that affect GHG emissions?

What areas of Surrey provide the best opportunity for reducing GHG emissions?

Our Project

Data

- ICBC vehicle registration[1]
- Transportation demand model output[1]
- Building and population projections[1]
- Census / StatCan data

[1] Thank you to the City of Surrey for providing these non-open data.

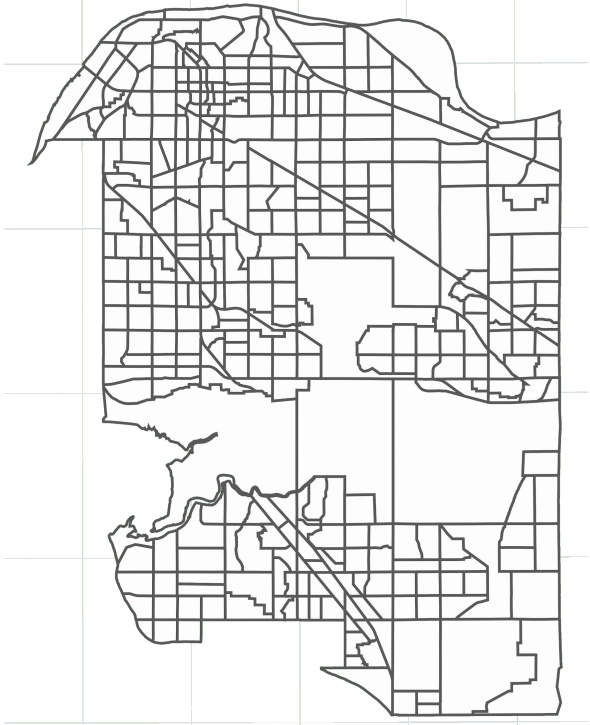
Process

1. Data Collections and Cleaning
    - Spatial Rebasing
2. Exploratory Data Analysis
3. Vehicle Stock Regression Modelling
    - Demographic, Transportation, Spatial/Temporal elements
4. Transportation Demand Classification by vehicle class
5. Emissions Modelling

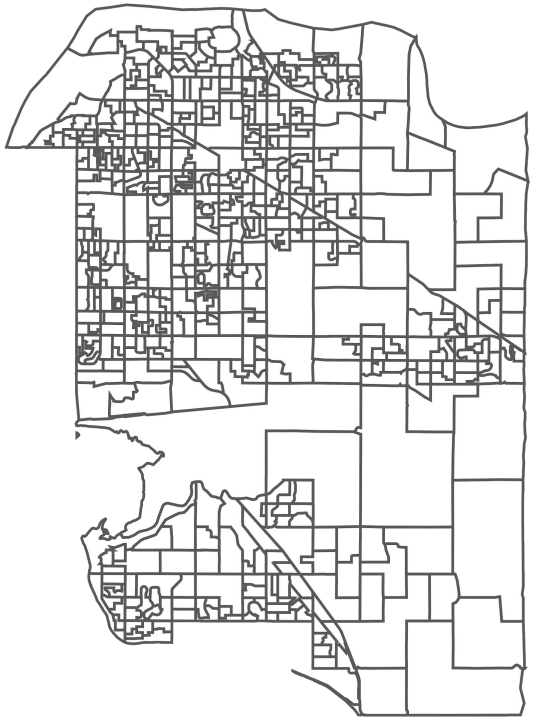
Geographical Rebasing

ICBC Registration:
Postal Codes

Transportation Models:
Traffic Analysis Zones



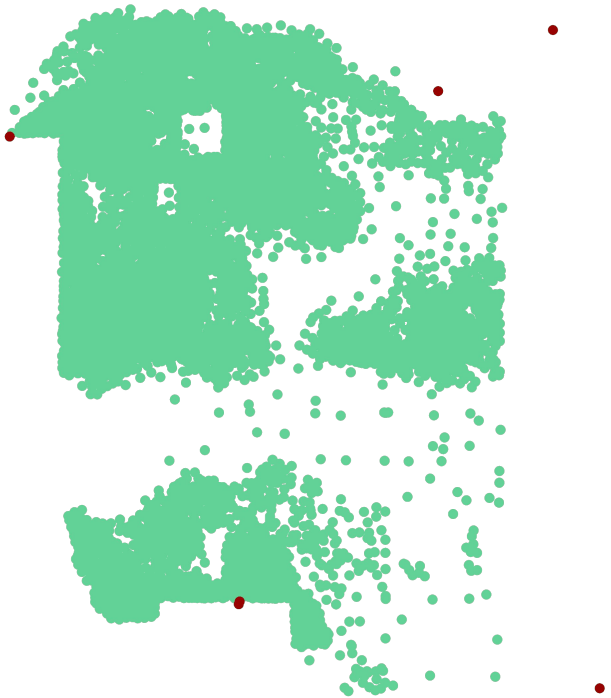
Census:
Dissemination Area



Sources:
City of Surrey, StatCan, Canada Post

Geographical Rebasing—Postal Codes

Approximate Postal Code catchment areas with their centroid.



Sources:
Canada Post, Google Maps API, geocoder.ca

Geographical Rebasing—Census Data

Goals of rebasing census data:

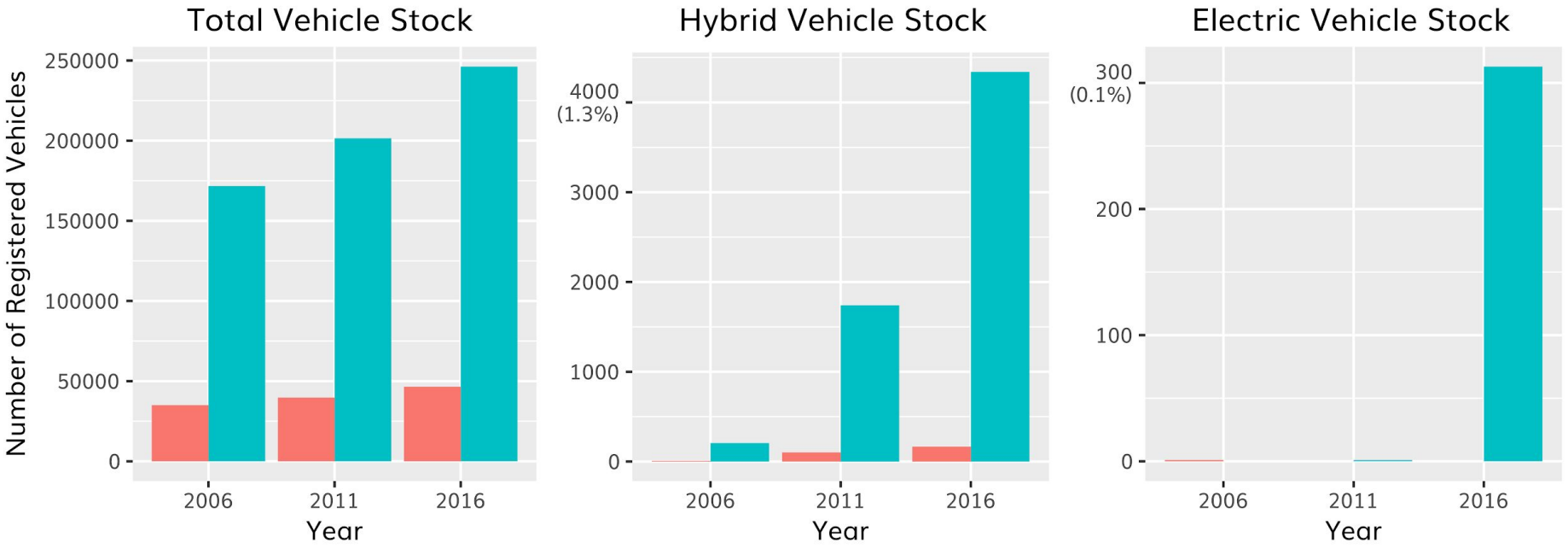
- Develop a TAZ-level table or database of all census variables relevant to transportation models (e.g.: vehicle stock models)
- Standardize all selected census variables across different years to a common set of variables

Issues with rebasing census data:

- No readily available interpolation / distribution algorithms
- Census population and housing stock may be under-estimated
- Census specification and vector names varies across the years.
- Standardization requires extensive “manual” adjustments

Resultant: 3 Census data table of 369 standardized variables for 374 TAZs

Vehicle Stock—Distribution of Vehicle Stock

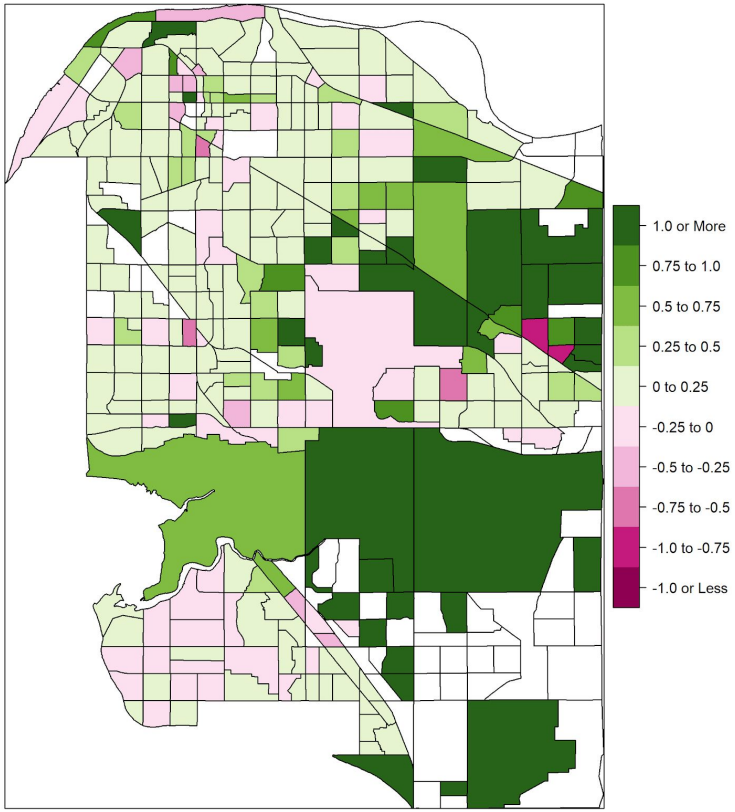


Green Vehicles early in its adoption, Further analysis focused on Passenger vehicle stock

Source:
ICBC Registration

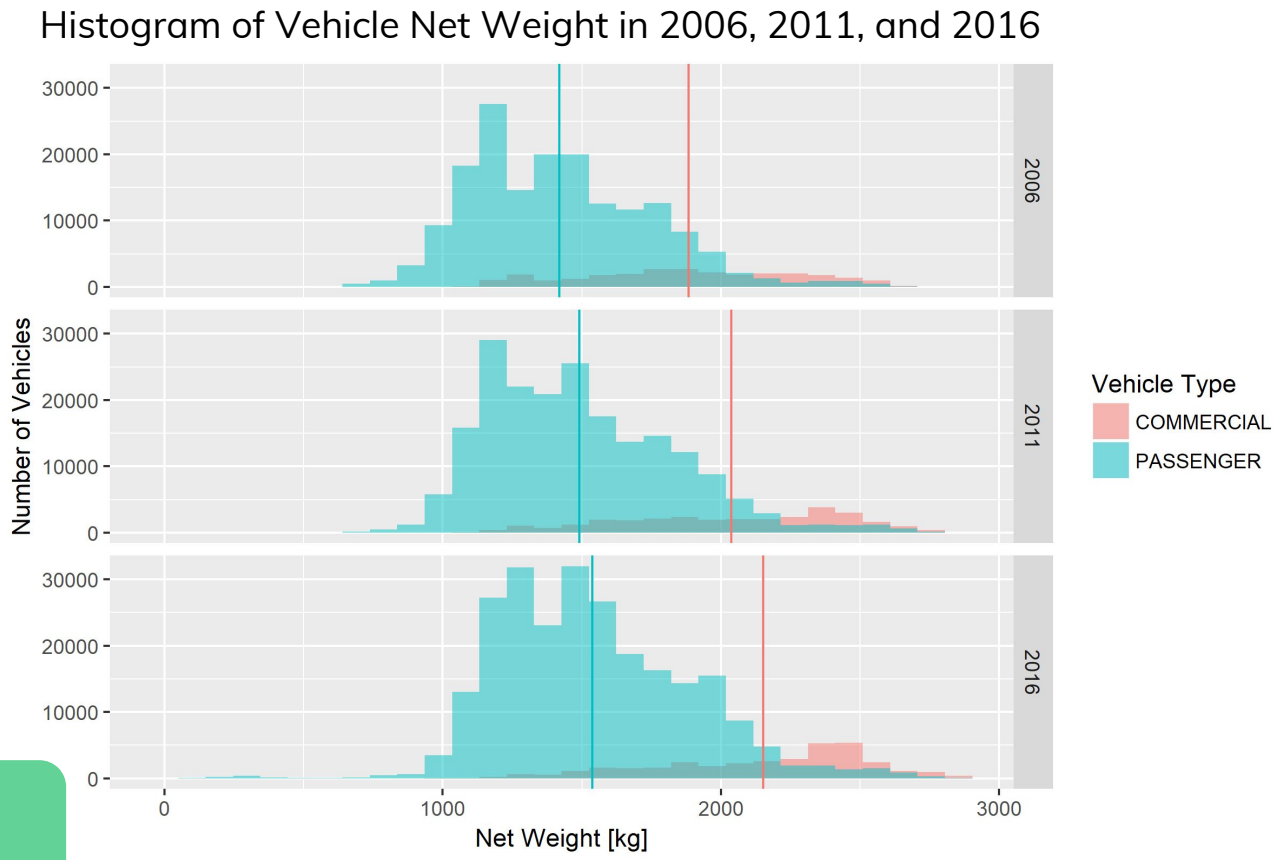
Vehicle Stock—Visualizing Vehicles Per Capita

Percent Change of Passenger Vehicles Per Capita Between 2006 and 2016



Source:
ICBC Registration

Vehicle Stock—Visualizing Vehicle Net Weight



Source:
ICBC Registration

Vehicle Stock—Changes in Vehicle Attributes

Vehicle per Capita	Vehicle Weight	Vehicle Age	TAZ Count	% of TAZ Count	% of TAZ by Pop. (in 2016)
↑ Vehicles Per Capita	↑ Weight	Older	195	52.14%	69.43%
		Younger	43	11.50%	11.92%
	↓ Weight	Older	5	1.34%	0.28%
		Younger	3	0.80%	0.99%
↓ Vehicles Per Capita	↑ Weight	Older	45	12.03%	9.25%
		Younger	11	2.94%	2.97%
	↓ Weight	Older	4	1.07%	0.23%
		Younger	2	0.53%	0.34%

Source:
ICBC Registration

Vehicle Stock—Next Steps and Data Gaps

1. Contextualize Findings: Variable Exploration with Demographic Variables
    - Understanding how vehicle ownership has changed in relation with other key demographic variables

2. Hypothesis Testing & Modelling: Obtain Unique Vehicle ID Between Years
    - Apply statistical testing for rigorous inference
    - Develop vehicle aging model to better understand vehicle ownership dynamics

Source:
ICBC Registration

Vehicle Classification

Purpose

Needed **Vehicle Classification Scheme** to various Make and Models that is not provided by ICBC dataset

And **Fuel Consumption Ratios** for passenger vehicles based on make, model, and year

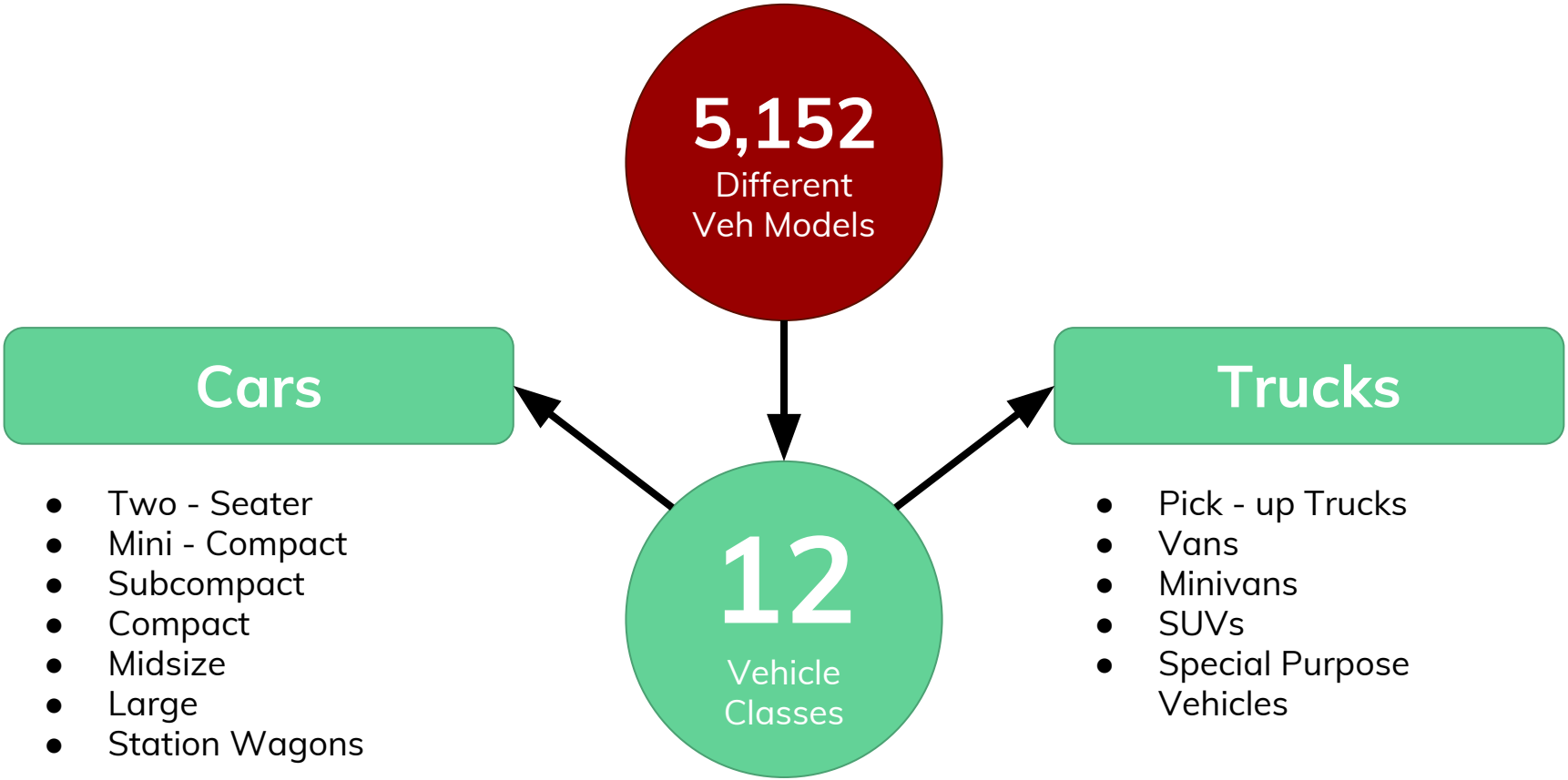
Method

Adopted classification scheme from **FuelEconomy**, a collaboration between U.S. Department of Energy and the Environmental Protection Agency (EPA)

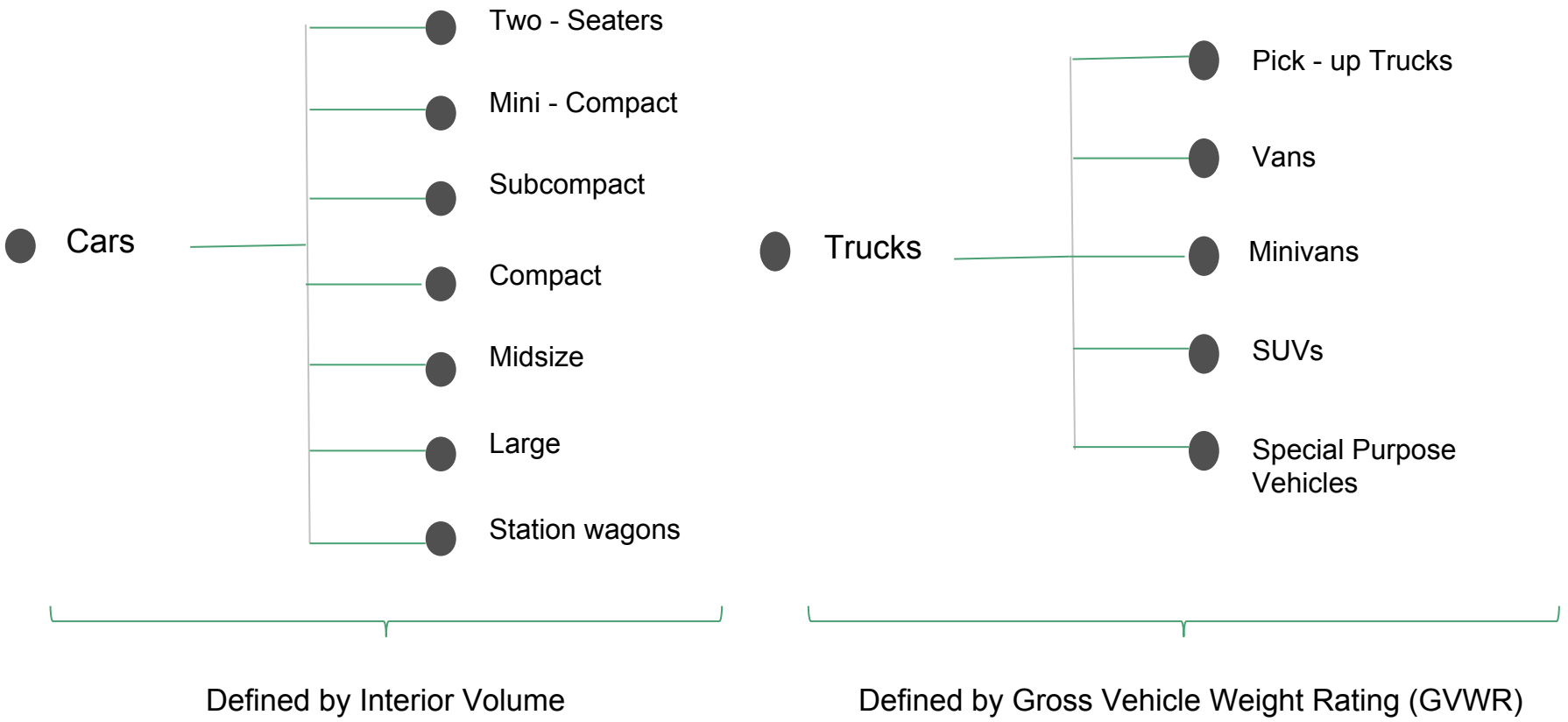
Vehicle Classification

- We decided to adopt a classification scheme from FuelEconomy which is a collaboration between U.S. Department of Energy and the Environmental Protection Agency (EPA)
- This classification offered us not only sufficient detail (with regards to different types of vehicles), it also provided us fuel consumption ratios for passenger vehicles based on make, model and year

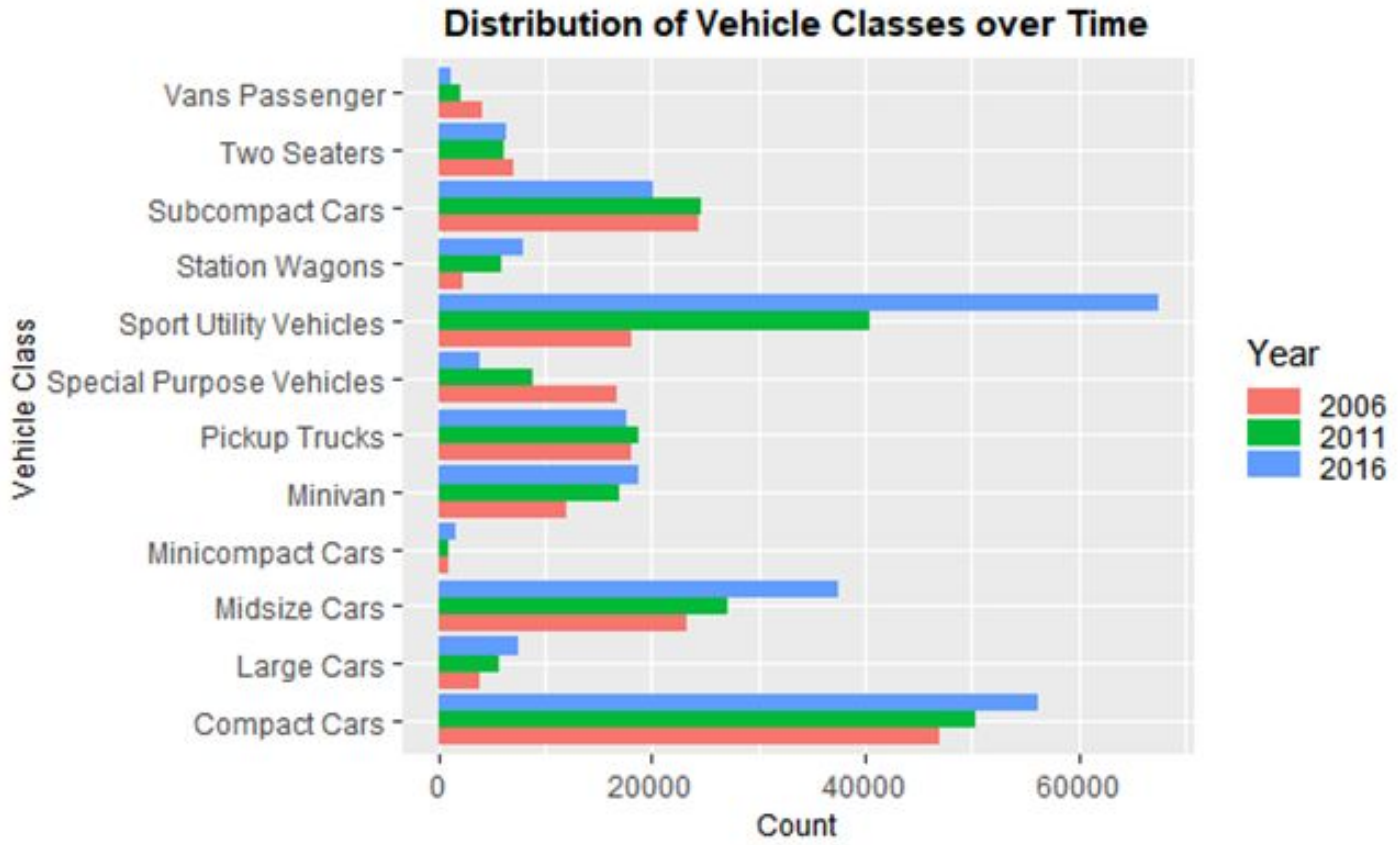
Vehicle Classification—Result



Vehicle Classification



Vehicle Classification—Distribution in ICBC Registry



Vehicle Stock Forecasting

Goal

- Provide Business-As-Usual (BAU) vehicle stock size forecasts for City of Surrey beyond the year of 2016

Challenges

- Need to account for geographic effects w/o necessarily interpreting them
- Need to account for effects of vehicle class
- Limited dataset size (only 3 time points)
  - Time series methods unfeasible
- Omitted variables may affect accuracy of the forecast
- For regression models, need future values of independent variables

Vehicle Stock Forecasting

Approach

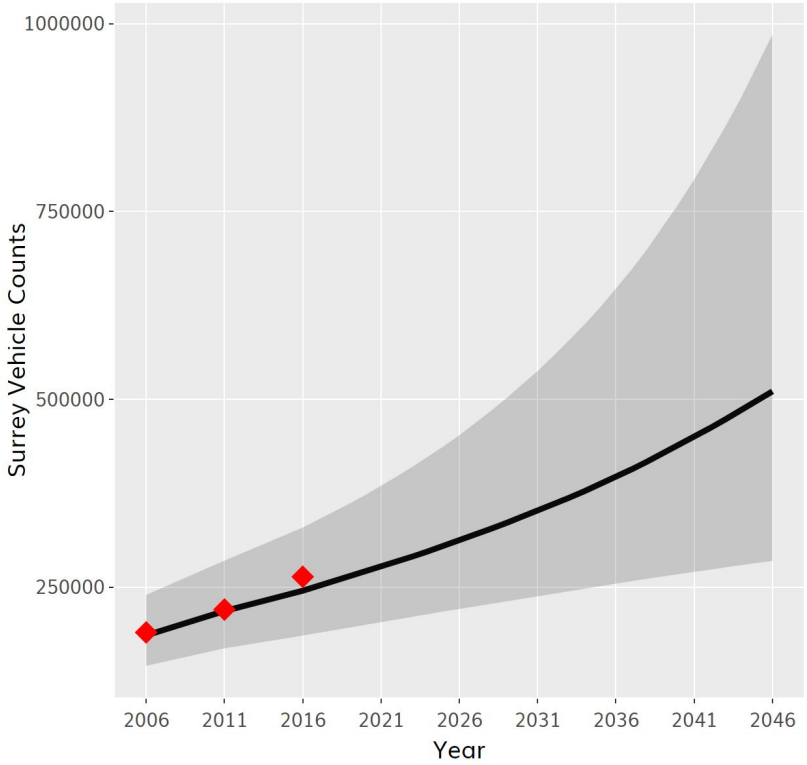
- Fit models at three geographic levels: city, community and TAZ
- Community models are the most sensible considering the data size
- Independent variables available: Year, Surrey Population & Housing
- WARNING: These prediction models do not yield valid and useable coefficients
    - Models are continuously modified to improve fit and diagnostics

Final community-level model

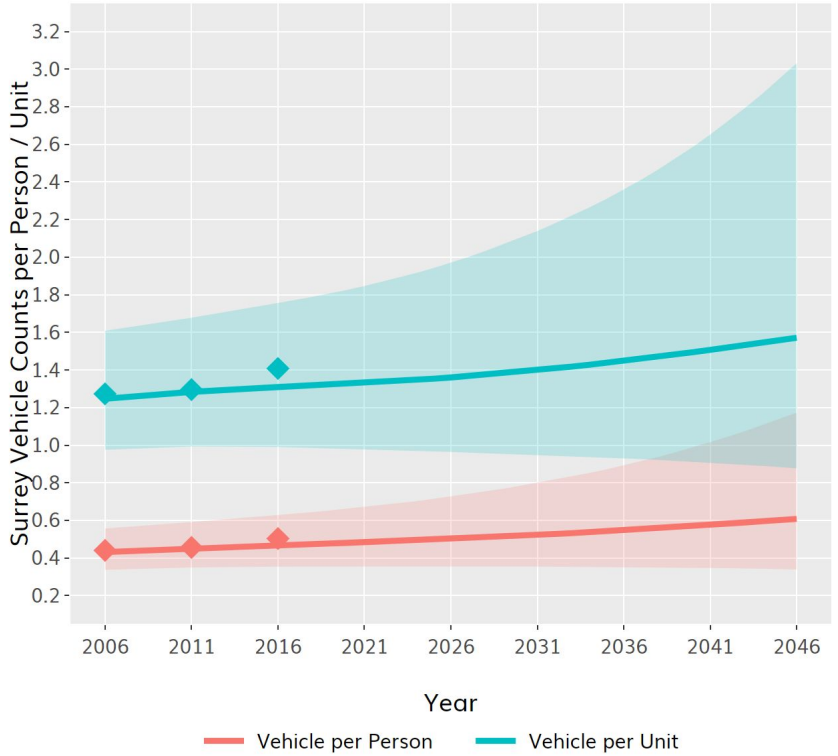
- Vehicle counts per community and vehicle class as a function of the community and community total units
- Variance of the model follows a log-normal distribution
- R^2 = 92%, Deviance Explained = 92.3%, with a sample size of 273
- Reasonable model diagnostics

Vehicle Stock Forecasting

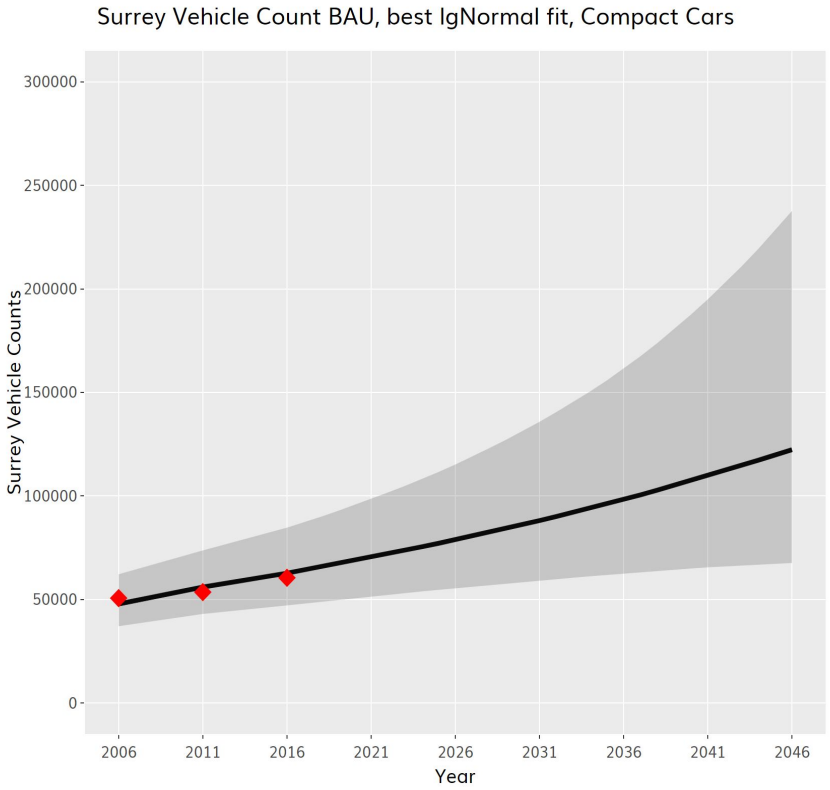
Surrey Vehicle Count BAU Log-Normal Model, with VClass

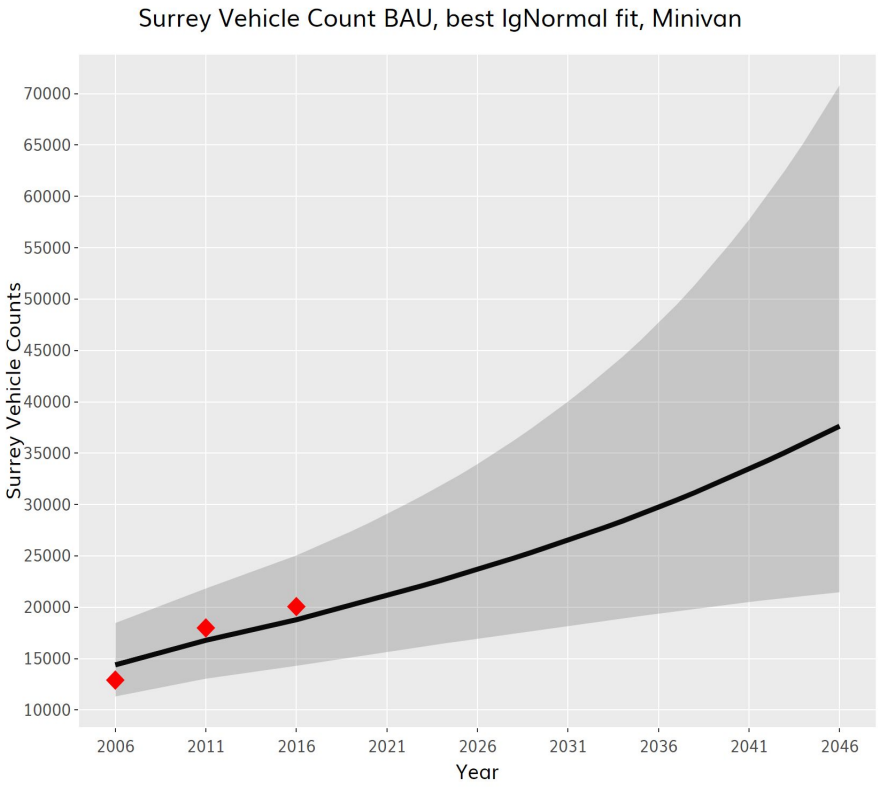


Surrey Vehicle BAU per cap Log-Normal Model, with VClass

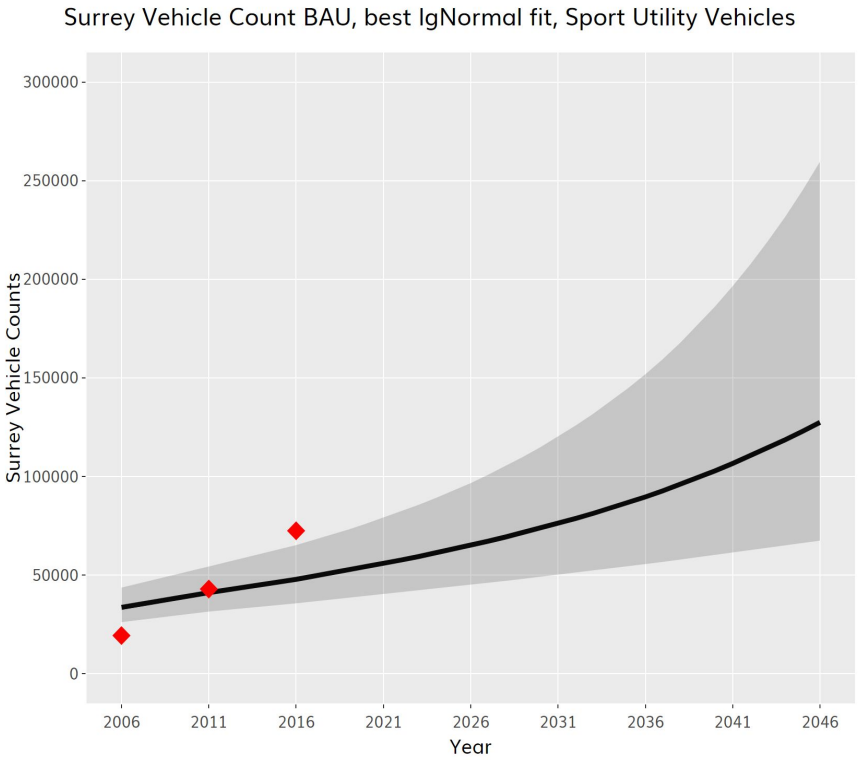


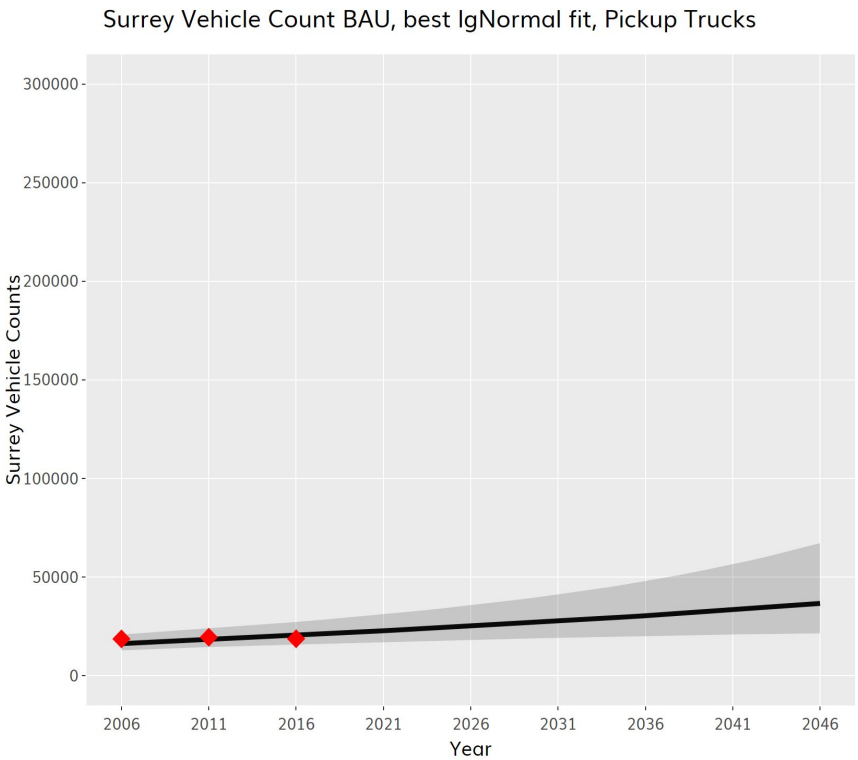
Vehicle Stock Forecasting



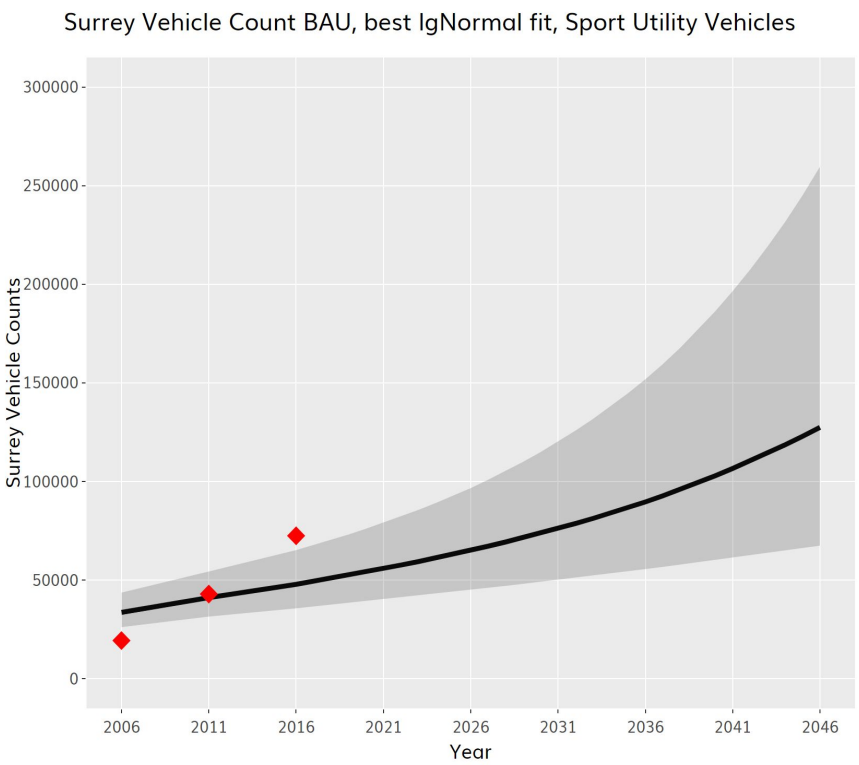


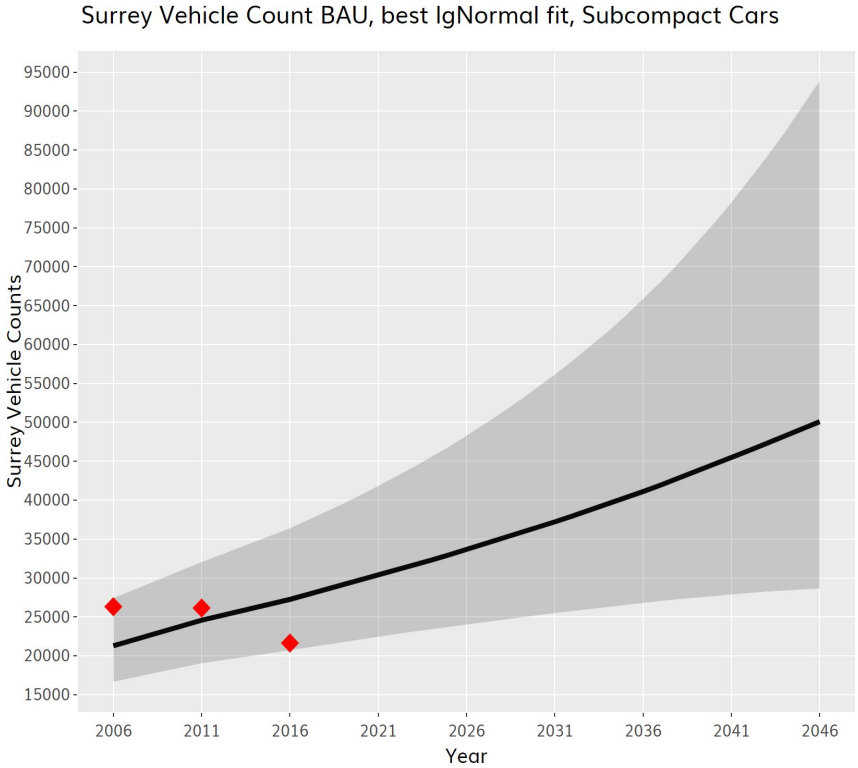
Vehicle Stock Forecasting



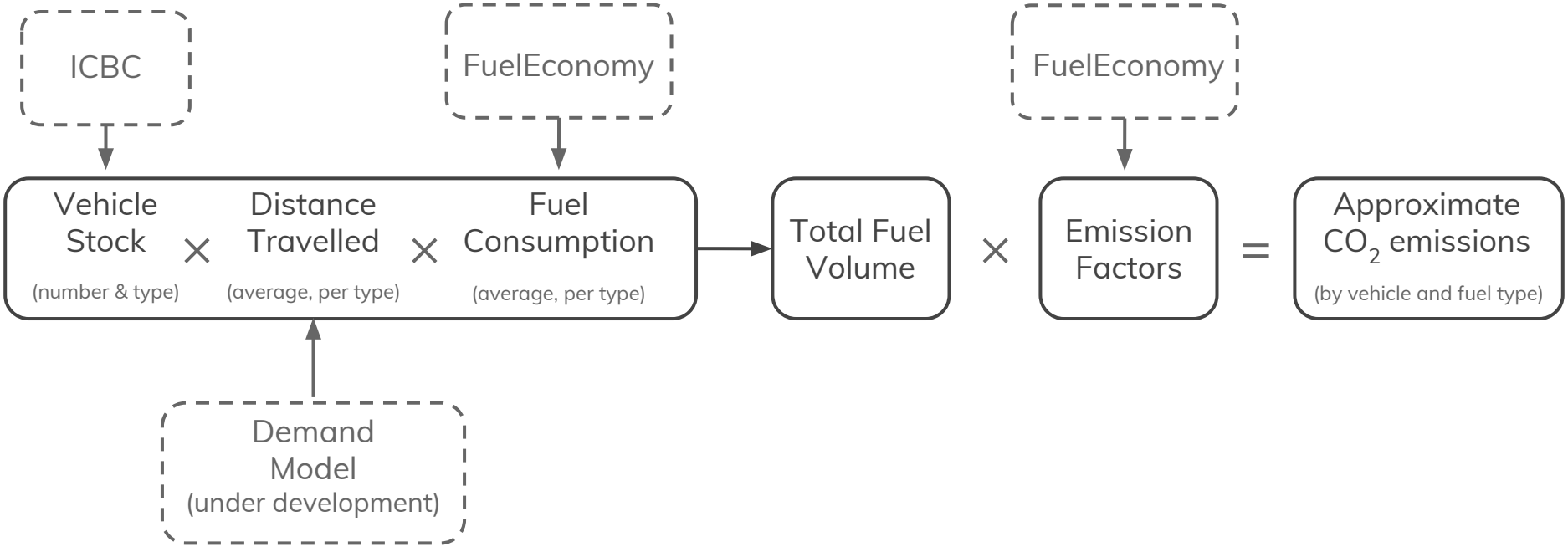


Vehicle Stock Forecasting





GHG Emission Inventories Methodology



Source:
IPCC (2006)
IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2, Chapter 3.

Next Steps

1. Regression Modelling of Vehicle Stock with Demographic Variables
2. More Advanced Modelling of Vehicle Stock (Markov Chain, Stock-Flow)
3. Validate and Redevelop Vehicle Stock Model with More Data
4. Compute GHG Emissions based on Vehicle Stock Forecasts once Transportation Demand Data is Made Available

Policy Analysis Tool

We’ve developed an interactive tool for planning and testing the outcomes of different policies in the City of Surrey.

Saved policies:

"Unsimulated Policy #1"

"Unsimulated Policy #2"

Policy: " Policy #1: All SUVs **"**

ID: 3

	2020	2030	2040	2050
Stock at date:				
Total Cars [#]	287985	337985	387985	437985
Stock inflow at date:				
Electric Vehicles[%]	0	0	0	0
Minicompact Cars[%]	0	0	0	0
Subcompact Cars[%]	0	0	0	0
Compact Cars[%]	0	0	0	0
Two Seaters[%]	0	0	0	0
Midsize Cars[%]	0	0	0	0
Large Cars[%]	0	0	0	0
Minivans[%]	0	0	0	0
SUVs[%]	100	100	100	100
Station Wagons[%]	0	0	0	0
Small Pickup Trucks[%]	0	0	0	0
Standard Pickup Trucks[%]	0	0	0	0
Vans[%]	0	0	0	0
Special Purpose[%]	0	0	0	0
Sum:	100%	100%	100%	100%

Notes:

Model parameters:

Emission factors:
EPA Combination

Interpolation:
Quadratic

Run analysis ▶

Policy Testing

Andy

localhost:5000/policy

Policy Testing Tool — *Compare th*

⟨ Hom

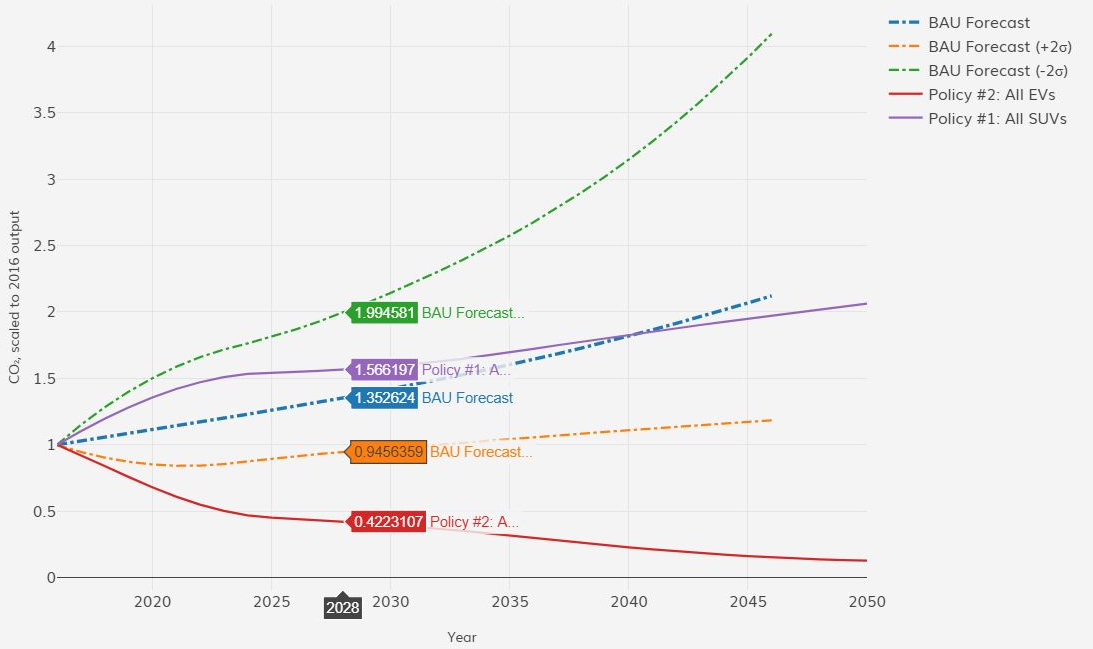
Saved policies:

"Unsimulated Policy #1"

"Unsimulated Policy #2"

Simulation completed.

Scaled GHG Comparison



Close results

Model parameters:

Emission factors:

EPA Combination

Interpolation:

Quadratic

Run analysis ▶

Questions?