Estimating the Effectiveness of Incentives on the Adoption of Electric Vehicles

BY: MICHELLE IMARAH, EIT & DR. GREG ERHARDT

1

Objectives

- Introduction
- Model estimation
- Scenarios
- Results
- Summary

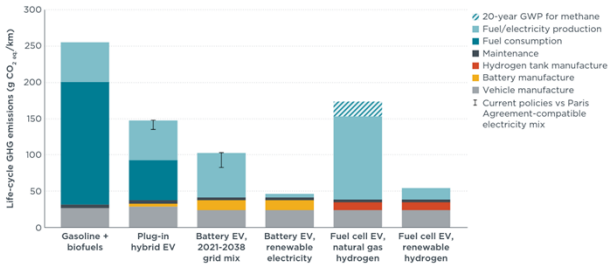
2

Introduction

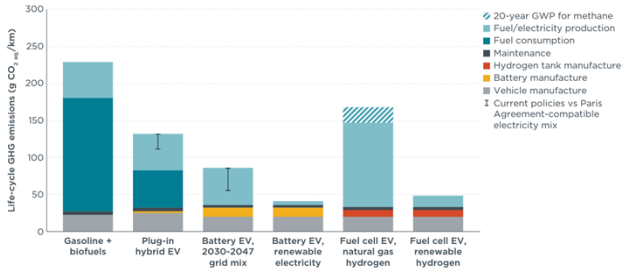
- Electric vehicles (EVs) are being reintroduced back into the car market as a possible solution to greenhouse gas emissions
- Other concerns like increased foreign oil dependency, increasing oil prices, global economic crisis and the consequences of climate change has sparked renewed interest in all alternative fuel vehicles, especially EVs
- In the global automotive market, EVs represent 26% of new sales (2021)
- The US Department of Energy reports that from 2014 till 2022, EV sales in the country have grown from 3% to 5.8% of new cars sold
- The Biden administration has however set an ambitious goal of 50% of new sales being EVs by 2030, with that figure rising to 64% by 2032

3

Energy Consumption



Lifecycle GHG emissions of passenger cars registered in the United States as of 2021



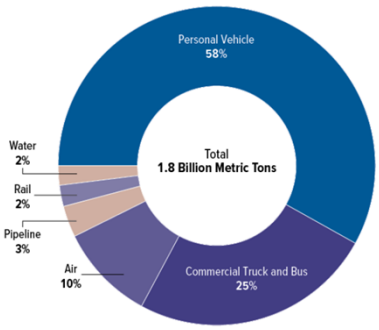
Lifecycle GHG emissions of passenger cars to be registered in the United States in 2030

4

Electric vehicle reception

- A study finds that 69% of respondents reported little to no familiarity with Plug-in electric vehicle (PEV) technology (Epstein et al., 2011).
- Another study also concluded that consumers tend to resist new technologies (Egbue and Long, 2012)
- Studies have also shown that perception and adoption of EVs vary by location comparing China to the US and finding that the Chinese are more willing to adopt than Americans
- Some studies, however, show that attitudes towards EVs changed largely after hands-on experience with the vehicles (Rezvani et al., 2015)
- Incentives and policies have been introduced in order to promote EV adoption

5



Vehicle Type Choice

- Vehicle type choice is an important dimension here and it also influences GHG emissions
- The United States is the second leader, in GHG emissions, accounting for 14% of the world's emissions
- The transportation sector accounts for 38% of emissions here in the US and 58% of that is produced from our personal vehicles
- Vehicle fleet composition of households is an important dimension and advancements in this has led to activity-based modelling
- Based on the demographics of households, we can predict the kind of vehicle they own, the vehicles they use in making tours, and the kind of tours a household can make based on their fleet

6

Problem Statement

- This study uses a multinomial logit model of vehicle type choice to calculate the probability of each household owning each available vehicle type alternative, where we consider body type, fuel type, and vehicle age
- The study goes further to test electric vehicle incentives based on scenarios and analyze the effect of each incentive on promoting electric vehicles amongst these households
- This study will be useful to transportation planners, policy makers, EV manufacturers and more in preparing us for the future of EVs

7

Data sources

- Erhardt et al's "Estimating and Implementing a Vehicle Type Model in an Activity Based Travel Model Framework' paper
- 2017 National Household Travel Survey (NHTS)
- US Environmental Protection Agency (EPA) fuel economy testing database
- California Energy Commission
- Beaureau Transportation of Statistics (BTS)
- US Department of Energy
- Plugshare

8

Methods

- Body type options: 'Car', 'Van', 'SUV', 'Pickup', 'Motorcycle'
- Fuel type options: 'Gas', 'Diesel', 'Hybrid', 'Plug-in Electric Vehicle (PEV)', 'Battery Electric Vehicle (BEV)'
- Vehicle age: 1 to 20 years
- Model estimation resulted in 194 coefficients
- The addition of incentives then creates different scenarios based on that incentive
- A restriction was added where if there are no models available for a vehicle type, the alternative is not available to the household

9

Key variables from the model

Variable	Alts/Segments	Coef.	T-Stat
LN (1+Number of Models Available)		0.605	47.56
LN (1+Number of Makes Available)		0.260	14.01
Miles per Gallon (or equivalent)		0.012	7.75
LN (Range for BEVs (mi))		3.752	18.59
BEV Range is less than average round-trip commute distance		-0.702	-1.70
LN (1+Chargers per capita in MSA/State)	BEV	1705.110	14.52
Chargers per sq mi in MSA or State		0.000018	7.64

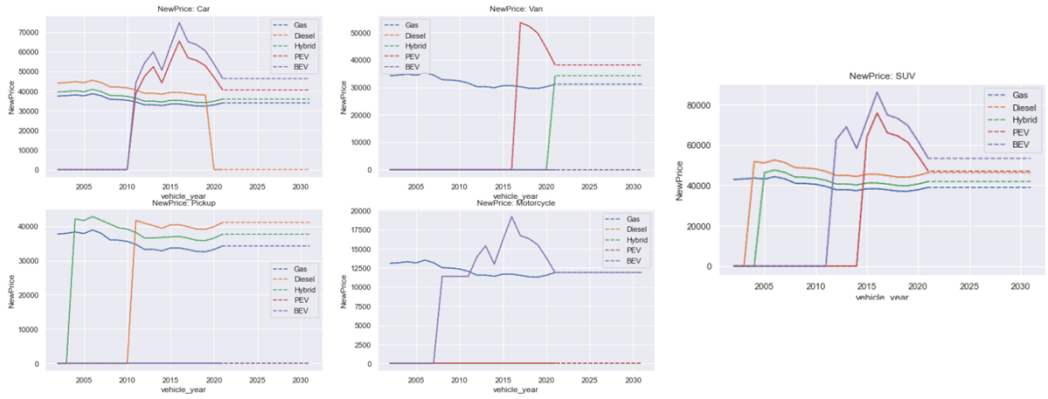
Variable	Alts/Segments	Coef.	T-Stat
Purchase Price of New Vehicle (2017 $)	Income $0-24k	-0.00011	-25.03
	Income $25-49k	-0.00010	-23.62
	Income $50-99k	-0.00009	-21.60
	Income $100-150k	-0.00008	-19.25
	Income $150k+	-0.00006	-14.62
	Income is Missing	-0.00008	-17.36
Income – Age (per year)	Income $0-24k	0.107	79.70
	Income $25-49k	0.047	43.22
	Income $100-150k	-0.037	-33.05
	Income $150k+	-0.071	-54.96
	Income is Missing	0.001	0.46

10

2031 base year

- We apply the model to a 2017 population while considering vehicle options that may be available in 2031
- We extend the 2021 current data on vehicle price, number of makes and models, and range 10 years towards 2031
- We choose 2031 as our base year as that is they year in which all incentives mentioned in the Inflation Reduction Act (IRA) expires
- Also, by 2031 we are ensured a range of option of vehicles up to 20 years old which will be the year 2012, the age limit used in the model

11



Graphs showing how the vehicle price as been extended from 2021 to 2031 in different vehicle types

12

Incentives

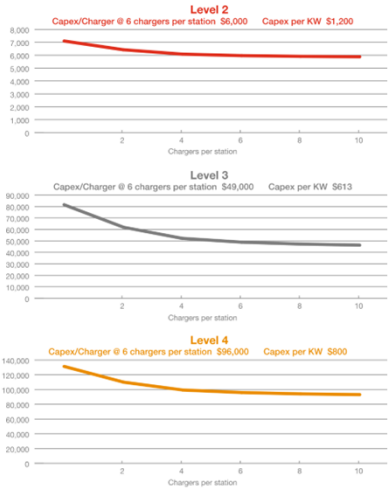
- Increase in chargers
- Reducing electric vehicle purchase price
- Increase in the number of EV makes and models
- Increase in EV driving range

13

Increase in chargers

- One of the biggest barriers to EV adoption is the limited number of chargers (Zhang et al, 2011)
- Consumers also raise concerns on also the lengthy charging times to refuel the cars (Graham-Rowe et al, 2012)
- A study estimates that buyers are willing to pay from $425 to $3520 per hour reduction in charging time (Hidrue et al, 2011)
- Charging infrastructure significantly influences per capita plug-in purchase
- Home charging is very key to consumers looking to purchase PEVs and BEVs
- There is however little consensus on how to direct investments in order to maximize the benefit per dollar spent on new charging infrastructure (Hardman et al, 2018)

14



capital expenditures per charger by level and station format in $ per charger

- level 1 and 2 chargers are usually found in the home and the workplace, and they usually satisfy a lot of the charging needs for users
- Places in Europe also have level 3 chargers which are specialized fast chargers, with an average 40-minute charge time for a 100-mile range
- DC or level 4 fast charging are quite expensive to install and serve few charging events. They have a 25-minute average charging time for a 100-mile range

15

Scenario 1 assumptions

- Bipartisan Infrastructure bill of 2021
- Increase investment in EV charging and create a national EV charging network with a goal set for 500,000 chargers to be built by 2030
- Currently 109,906 public chargers in the US
- Scenario:
  - *Increase the number of chargers by 455% to achieve the goal of 500,000*
- Multiplied the chargers per capita and per mile by 5.55 and cross referenced it with the survey for each household
- Utility equations apply the charger coefficient only to BEVs

16

Results

- Moderate decrease amongst gas, diesel, hybrids and PEVs
- Moderate increase in BEVs

	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario 1 (number of vehicles)					
Gas	48,939,312	40,488,899	55,676,972	59,819,488	204,924,671
Diesel	1,210,712	1,003,616	1,280,697	810,579	4,305,604
Hybrid	2,715,958	2,195,512	1,945,893	1,585,491	8,442,853
PEV	1,715,076	1,387,190	703,255	126,502	3,932,023
BEV	1,557,517	1,238,793	535,549	17,922	3,349,781
Total	56,138,576	46,314,009	60,142,366	62,359,982	224,954,932
Percent Difference					
Gas	-0.02%	-0.02%	-0.02%	-0.01%	-0.02%
Diesel	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%
Hybrid	-0.03%	-0.03%	-0.02%	-0.02%	-0.03%
PEV	-0.04%	-0.03%	-0.03%	-0.03%	-0.04%
BEV	**1.33%**	**1.25%**	**1.24%**	**1.26%**	**1.29%**
Total	0.01%	0.01%	-0.01%	-0.01%	0.00%

17

Reducing EV purchase price

- Prices of EVs remain a dominant barrier to widespread adoption
- A lot of consumers are concerned about the financial implications of purchasing EVs (Graham-Rowe, 2012)
- A literature review discussing consumer preferences for EVs finds purchase price to have a negative and high significant influence on the EV utility in all studies (Liao et al, 2016).
- The high purchase cost of EVs could also be attributed to the high cost of the battery on which it runs, and battery cost must drop significantly before EVs will find a mass market without subsidy (Hidrue et al, 2011)
- On the other hand, a study found that those who are open to purchasing PEVs will pay an average of $1858 more to save $500/year in gas (Krupa et al, 2014)
- A lot of consumers will rather purchase a PEV over a BEV
- Krupa also found that incentives like rebates and tax credits, applied at point of sale to be the most effective at promoting EVs
- Today, however, we do see as EVs are getting more popular, that prices are coming down and ownership costs are getting lower

18

Scenario 2 assumptions

- Inflation Reduction Act of 2022
- It provides a $4,000 consumer tax credit for lower- and middle-income individuals to buy used-clean vehicles for less than $25,000, and up to $7,500 tax credit to buy new clean vehicles
- EVs must be assembled in North America in order to be eligible for the $7500 tax credit and 40% of metals must come from North America or a free-trade partner.
- Single people who earn more than $150,000 a year and couples who earn more than $300,000 a year will not be eligible for any form of EV tax credit
- The new EV tax credit will be a point-of-sale credit
- Scenario:
  - *reducing the price of EVs by $6,000 for HH incomes less than $50,000*
  - *For HH incomes between $50,000 and $150,000, reduce the EV price by $2,000;* and
  - *For Households earning more than $150,000, EV prices are unchanged*

19

Results

- decrease in gas, diesel, and hybrid vehicles by a small percentage
- PEVs and BEVs have increased by over 20% in the vehicle share
- Findings are in line with the literature review

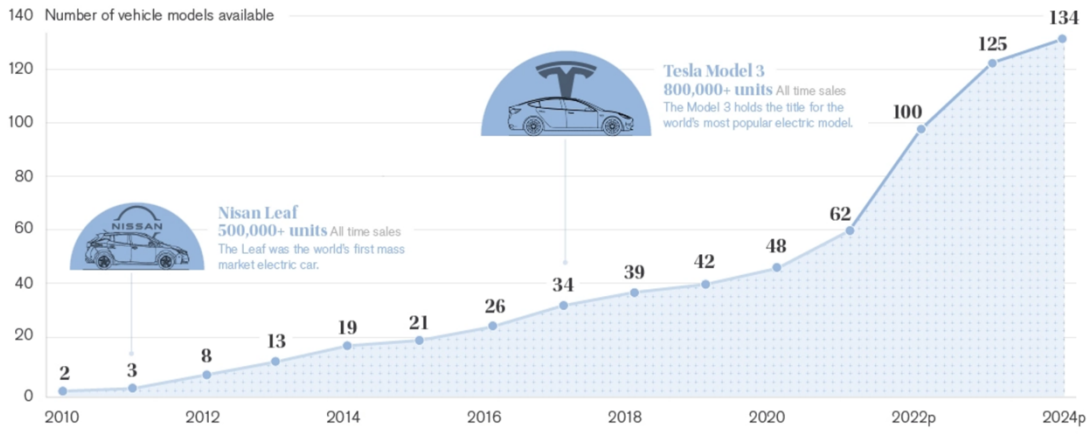
	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario 2 (number of vehicles)					
Gas	48,593,092	40,165,961	55,181,434	59,234,894	203,175,380
Diesel	1,203,420	996,783	1,270,719	803,036	4,273,957
Hybrid	2,694,908	2,176,007	1,926,606	1,567,815	8,365,335
PEV	2,130,947	1,797,499	929,327	176,829	5,034,601
BEV	1,861,400	1,542,277	678,479	23,504	4,105,659
Total	56,483,767	46,678,525	59,986,564	61,806,076	224,954,932
Percent Difference					
Gas	-0.7%	-0.8%	-0.9%	-1.0%	-0.9%
Diesel	-0.6%	-0.7%	-0.8%	-0.9%	-0.8%
Hybrid	-0.8%	-0.9%	-1.0%	-1.1%	-0.9%
PEV	**24.2%**	**29.5%**	**32.1%**	**39.7%**	**28.0%**
BEV	**21.1%**	**26.1%**	**28.3%**	**32.8%**	**24.1%**
Total	0.6%	0.8%	-0.3%	-0.9%	0.0%

20

Increasing number of EV makes and models

- Limited peer-reviewed journals on how more options of makes and models affects EV adoption
- Higher EV market share increases EV preference (Liao et al, 2016)
- There is a demand for the electrification of pickup trucks and SUVs, these popular models will have an impact on adoption in the US (Hensley, 2022)
- Six automakers and 30 countries signed a pledge to end the sales of gas and diesel-powered cars worldwide by 2040 (Miller, 2021)
- Major industry players in the EV market include Tesla, Karma, Lucid, Rivian, Lordstown, Nikola
- Tesla is currently in the lead of selling the most EVs, selling around 360,000 units in the US in 2022

21



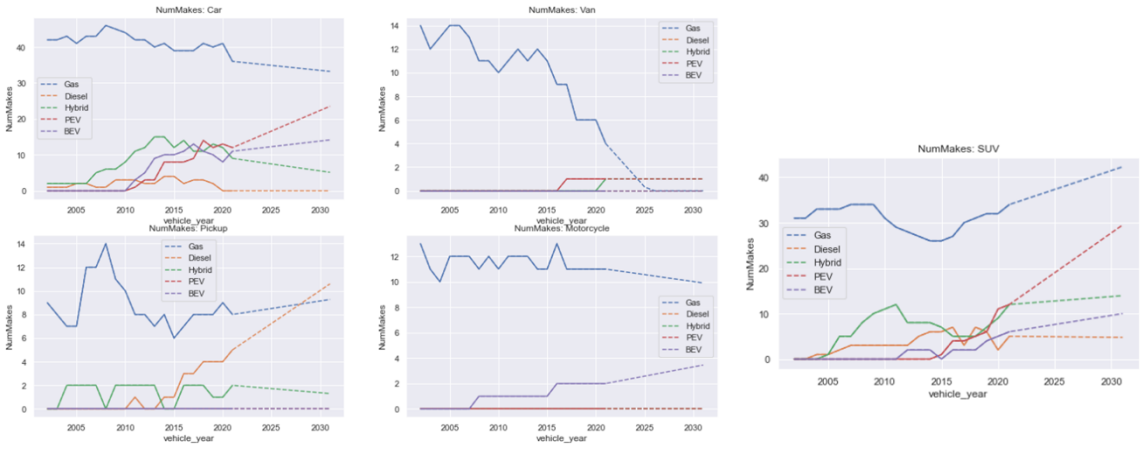
Graph showing how EV models have and may increase over the years

22

Scenario 3 assumptions

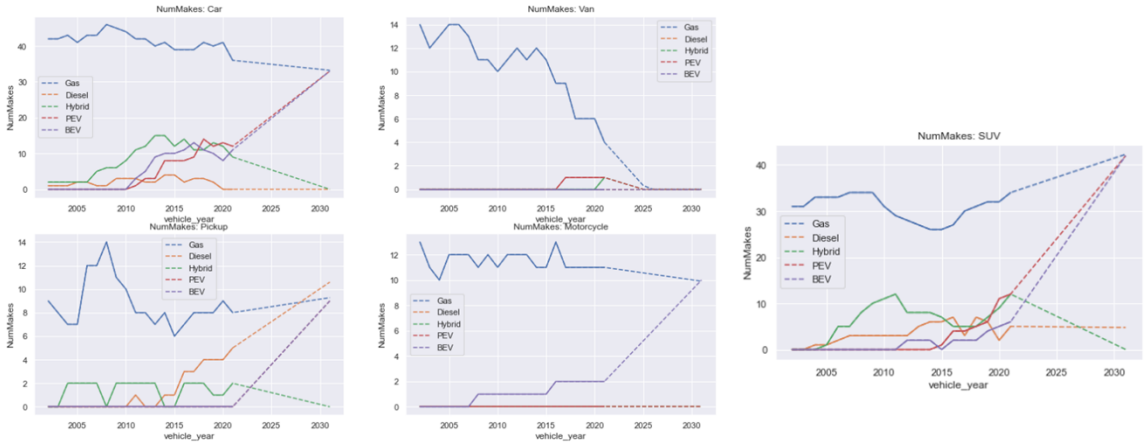
- Two scenarios were created: MM1 and MM2
- MM1 Scenario:
  - *Continue existing trends with the number of makes and models*
  - *From this, it projects gas, diesel, and hybrids to reduce in number towards 2031*
  - *Pickup-diesel is an exception which still sees increase in trends*
  - *PEVs and BEVs increase in number*
  - *Exceptions include pickups and vans that have 1 or 0 makes and models for BEVs and PEVs*
  - *Motorcycles have no makes or models for diesel, hybrids, and PEVs*
- MM2 Scenario:
  - *Gas and diesel continue existing trends*
  - *Vans will have zero models for all types by 2031*
  - *Hybrids will phase out by 2031 in favor of more PEVs*
  - *Every other vehicle will be available with a gas, PEV, and BEV option by 2031*

23



MM1 trends

24



MM2 trends

25

MM1 results

- little decrease in gas vehicles of less than 2%
- significant increases in EVs, specifically plug-ins with over 35% increase
- increase in diesel vehicles by 18%
- BEVs also have a strong increase of over 20%

	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario 3 (number of vehicles)					
Gas	48,716,723	39,600,166	54,543,052	58,777,281	201,637,223
Diesel	1,848,592	1,186,833	1,253,188	795,474	5,084,086
Hybrid	3,048,791	2,271,036	1,903,234	1,555,983	8,779,044
PEV	2,891,034	1,714,918	686,106	123,858	5,415,916
BEV	2,132,118	1,375,488	513,819	17,239	4,038,664
Total	58,637,258	46,148,441	58,899,398	61,269,835	224,954,932
Percent Difference					
Gas	-0.5%	-2.2%	-2.1%	-1.8%	-1.6%
Diesel	52.7%	18.2%	-2.2%	-1.9%	18.1%
Hybrid	12.2%	3.4%	-2.2%	-1.9%	4.0%
PEV	**68.5%**	**23.6%**	-2.5%	-2.1%	**37.7%**
BEV	**38.7%**	**12.4%**	-2.9%	-2.6%	**22.1%**
Total	4.5%	-0.3%	-2.1%	-1.8%	0.0%

26

MM2 results

- Significantly higher results here
- Gas, diesel, and hybrids greatly decrease, with hybrids decreasing at over 70%
- conventional gas vehicles decrease by over 50% as well
- PEVs and BEVs have very high increases in percentage

	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario 3 (number of vehicles)					
Gas	21,273,517	16,950,301	23,078,960	24,807,532	86,110,309
Diesel	799,946	504,450	527,027	335,965	2,167,388
Hybrid	314,762	679,022	780,514	633,533	2,407,831
PEV	34,917,727	14,036,188	268,028	47,808	49,269,750
BEV	60,519,815	24,286,677	186,949	6,213	84,999,654
Total	117,825,767	56,456,637	24,841,478	25,831,051	224,954,932
Percent Difference					
Gas	-56.5%	-58.1%	-58.6%	-58.5%	-58.0%
Diesel	-33.9%	-49.7%	-58.9%	-58.6%	-49.7%
Hybrid	-88.4%	-69.1%	-59.9%	-60.0%	-71.5%
PEV	**1935.1%**	**911.5%**	-61.9%	-62.2%	**1152.6%**
BEV	**3837.5%**	**1885.1%**	-64.7%	-64.9%	**2470.2%**
Total	109.9%	21.9%	-58.7%	-58.6%	0.0%

27

MM1 VS MM2

- Both models tell us something different about the state of EVs
- MM1 tells us that if manufacturers and policy makers continue with creating EVs at our current rate, by 2031, we will have a moderate increase in EVs but a very low decrease in gas vehicles
- MM2, on the other hand, tells us that if we take more drastic measures like cutting off production of hybrids and matching EVs to that of conventional fuel vehicles, there will be a far more significant impact of consumers purchasing EVs

28

Increasing EV driving range

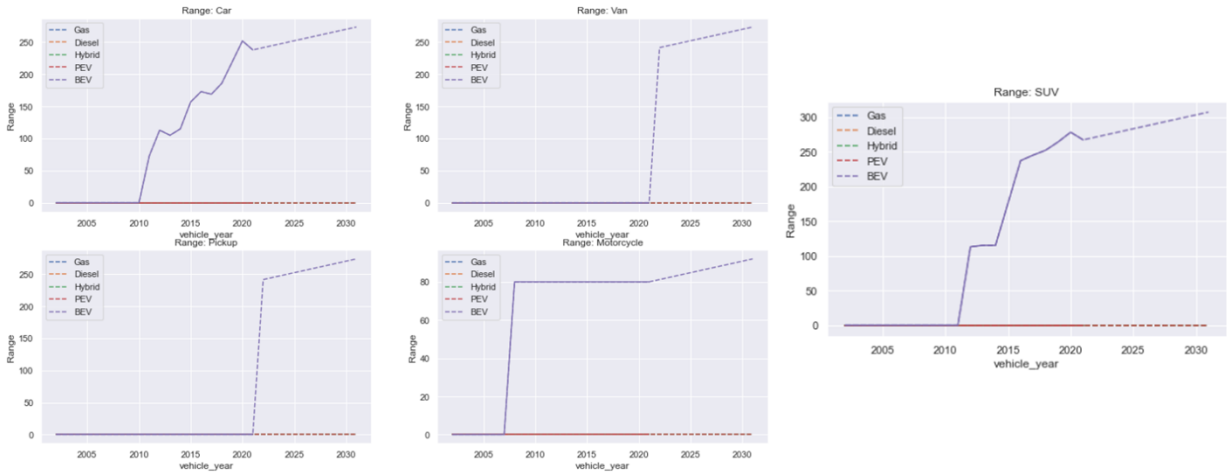
- Perceived short driving range has been a major limitation to large scale adoption of BEVs
- The term 'range anxiety' has been coined which is the fear that an electric vehicle may not have enough battery charge to reach its destination
- A meta-analysis of consumer preferences for alternative fuel vehicles found that consumers are willing to pay $66 to $75 for a 1-mile increase in driving range (Dimitropoulos et al, 2013)
- For energy-efficiency tradeoffs, a 10 kWh increase in battery capacity increases the mass of electric cars by 15 kg, their drive range by 40–50 km, and their energy consumption by 0.7–1.0 kWh/100 km (Weiss et al, 2020)
- High energy density is important to minimize the total weight of the battery while still storing as much energy as possible to maximize the car's range
- More public charging infrastructure can ease range anxiety
- As of 2020, the average range of a BEV was 187 miles, and it is projected to be 275 miles by 2030 (Carlier, 2022)

29

Scenario 4 assumptions

- This range scenario only applies to BEVs as it runs solely on battery and does not have an extra motor
- Scenario:
  - *Increase the range by 1.5% per year linearly*

30



Range trends

31

Results

- Overall decrease in all other fuel types
- Rise in BEV share, around 50% increase
- However, the small decreases in other fuel types tell us that range alone may not be enough to drastically reduce the use of conventional vehicles

	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario 4 (number of vehicles)					
Gas	48,689,283	40,306,211	55,456,725	59,620,731	204,072,951
Diesel	1,204,805	999,307	1,275,837	807,681	4,287,630
Hybrid	2,698,875	2,183,164	1,936,172	1,578,828	8,397,039
PEV	1,702,569	1,378,049	698,826	125,799	3,905,242
BEV	2,330,486	1,420,602	523,453	17,529	4,292,070
Total	56,626,019	46,287,333	59,891,013	62,150,568	224,954,932
Percent Difference					
Gas	-0.5%	-0.5%	-0.4%	-0.3%	-0.4%
Diesel	-0.5%	-0.4%	-0.4%	-0.4%	-0.4%
Hybrid	-0.7%	-0.6%	-0.5%	-0.4%	-0.6%
PEV	-0.8%	-0.7%	-0.7%	-0.6%	-0.7%
BEV	**51.6%**	**16.1%**	-1.0%	-1.0%	**29.8%**
Total	0.9%	0.0%	-0.4%	-0.4%	0.0%

32

All scenarios

- We will be testing all scenarios together in the model
  - Increasing number of chargers by 455%
  - Decreasing price based in household groups
  - Increasing the number of models and makes using MM1 and MM2
  - Increasing the BEV range
- Section will be divided into: All scenarios using MM1 and All scenarios using MM2

33

All Scenarios using MM1

	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario 5 (number of vehicles)					
Gas	47,841,871	38,875,715	53,523,299	57,671,903	197,912,789
Diesel	1,818,929	1,167,551	1,232,044	780,694	4,999,218
Hybrid	2,985,396	2,222,697	1,861,984	1,521,700	8,591,777
PEV	3,540,924	2,192,149	896,340	171,303	6,800,717
BEV	3,942,369	2,029,745	655,504	22,813	6,650,431
Total	60,129,490	46,487,857	58,169,172	60,168,413	224,954,932
Percent Difference					
Gas	-2.3%	-4.0%	-3.9%	-3.6%	-3.4%
Diesel	50.2%	16.3%	-3.8%	-3.7%	16.1%
Hybrid	9.9%	1.2%	-4.3%	-4.0%	1.7%
PEV	**106.4%**	**58.0%**	**27.4%**	**35.4%**	**72.9%**
BEV	**156.5%**	**65.9%**	**23.9%**	**28.9%**	**101.1%**
Total	7.1%	0.4%	-3.3%	-3.5%	0.0%

34

All Scenarios using MM2

	Age				
Fuel Type	1 to 5 years	6 to 10 years	11 to 15 years	16-20+ years	Total
Base (number of vehicles)					
Gas	48,951,048	40,497,062	55,686,560	59,828,222	204,962,892
Diesel	1,210,990	1,003,807	1,280,906	810,708	4,306,411
Hybrid	2,716,788	2,196,091	1,946,342	1,585,803	8,445,024
PEV	1,715,757	1,387,673	703,492	126,541	3,933,462
BEV	1,537,011	1,223,441	528,991	17,699	3,307,142
Total	56,131,595	46,308,074	60,146,292	62,368,972	224,954,932
Scenario (number of vehicles)					
Gas	16,181,498	12,506,072	16,480,776	17,054,148	62,222,494
Diesel	612,510	375,733	380,103	234,820	1,603,166
Hybrid	237,911	499,343	557,104	433,363	1,727,721
PEV	32,390,026	13,224,317	247,484	45,150	45,906,977
BEV	85,994,712	27,324,579	169,567	5,716	113,494,574
Total	135,416,658	53,930,044	17,835,035	17,773,196	224,954,932
Percent Difference					
Gas	-66.9%	-69.1%	-70.4%	-71.5%	-69.6%
Diesel	-49.4%	-62.6%	-70.3%	-71.0%	-62.8%
Hybrid	-91.2%	-77.3%	-71.4%	-72.7%	-79.5%
PEV	**1787.8%**	**853.0%**	**-64.8%**	**-64.3%**	**1067.1%**
BEV	**5494.9%**	**2133.4%**	**-67.9%**	**-67.7%**	**3331.8%**
Total	141.2%	16.5%	-70.3%	-71.5%	0.0%

35

Findings from All Scenarios

- For all of the above (MM1), we see decreases in gas vehicles, but some increase in diesel and hybrids as well
- Compared to all of the above (MM2), where gas, diesel, and hybrid drop by a significant amount
- In both scenarios, however, we see PEVs and BEVs increase remarkably by as much as 100% in MM1 and 3000% in MM2

36

Summary

Fuel Type	Base	Chargers	Price	Makes and models 1	Makes and models 2	Range	All of the Above (MM1)	All of the Above (MM2)
	Number of Vehicles							
Gas	204,962,892	204,924,671	203,175,380	201,637,223	86,110,309	204,072,951	197,912,789	62,222,494
Diesel	4,306,411	4,305,604	4,273,957	5,084,086	2,167,388	4,287,630	4,999,218	1,603,166
Hybrid	8,445,024	8,442,853	8,365,335	8,779,044	2,407,831	8,397,039	8,591,777	1,727,721
PEV	3,933,462	3,932,023	5,034,601	5,415,916	49,269,750	3,905,242	6,800,717	45,906,977
BEV	3,307,142	3,349,781	4,105,659	4,038,664	84,999,654	4,292,070	6,650,431	113,494,574
Total	224,954,932	224,954,932	224,954,932	224,954,932	224,954,932	224,954,932	224,954,932	224,954,932
	Percent Difference from base							
Gas	0.0%	-0.02%	-0.9%	-1.6%	-58.0%	-0.4%	-3.4%	-69.6%
Diesel	0.0%	-0.02%	-0.8%	18.1%	-49.7%	-0.4%	16.1%	-62.8%
Hybrid	0.0%	-0.03%	-0.9%	4.0%	-71.5%	-0.6%	1.7%	-79.5%
PEV	0.0%	-0.04%	28.0%	37.7%	1152.6%	-0.7%	72.9%	1067.1%
BEV	0.0%	1.29%	24.1%	22.1%	2470.2%	29.8%	101.1%	3331.8%

37

Limitations to the study

- Estimated from data based on the 2017 National Household Travel Survey
- Data like price, number of models, range are also retrieved from 2021
- 2031 base fleet is based on assumptions
- Made use of different methods of forecasting in order to reach the projected estimations over the years
- It is a cross-sectional study
- It is hard to measure the true changes especially over periods of time

38

E.P.A. Is Said to Propose Rules Meant to Drive Up Electric Car Sales Tenfold

In what would be the nation's most ambitious climate regulation, the proposal is designed to ensure that electric cars make up the majority of new U.S. auto sales by 2032.

Future work

https://www.nytimes.com/2023/04/08/climate/biden-electric-cars-epa.html?smid=nytcore-ios-share&referringSource=articleShare

- Biden administration announced for auto-pollution limits in order to ensure 67% of new passenger cars sold in 2032 are all-electric
- Climate policy experts have found that nations would have to phase out sales of new gasoline vehicles by 2035 to prevent average global temperatures from increasing by 2.7-degree Fahrenheit

39