Los Angeles County:
Transport Emissions from Gasoline, Diesel, E85 Biofuel, and Electric Vehicles
Emissions Inventory and Mitigation Potentials

Zoë Gagalis
ESS 545: Applications in Greenhouse Gas Inventories
12 April, 2025

Executive Summary

The car-centric culture in Los Angeles combined with the urban sprawl and large land area of the county create an environment where personal transportation is responsible for a very significant portion of greenhouse gas emissions. Therefore, the objective of this study was to conduct an inventory of greenhouse gas emissions for transportation in Los Angeles County, California, including combustion of gasoline, diesel, E85 biofuel, and emissions generated from electricity used to power electric (zero-emission) vehicles. From here, it is necessary to perform a mitigation analysis to assess the extent and possibility of decreasing greenhouse gas emissions from transportation by slowly decreasing tailpipe emissions in LA County. The inventory time series is from the year 2010 to 2020, and is based on Tier 1 methods from the International Panel on Climate Change (IPCC). Emissions are estimated in CO_2 equivalent emissions, and include CO_2, methane and nitrous oxide emissions from combustion of gasoline, diesel and electricity generation. The inventory aimed to demonstrate the changes in greenhouse gas emissions throughout the 10 year time period of interest, illustrating the growing popularity of zero-emission electric vehicles and biofuels. In total, the study estimated CO_2 equivalent emissions of 130,816.47 Gg in 2010, 132,446.61 Gg in 2015, and 124,851.41 Gg in 2020, showing an increase between 2010 and 2015, and then a decrease in 2020. In conjunction with data on the amounts of fuel sold within Los Angeles County during these years, these numbers paint a picture of a rapidly expanding industry for zero-emission vehicles, as the emissions drop sharply after the modest increase from 2010-2015.

Introduction

Los Angeles County, with a population of almost 10 million people, has long been known for the traffic that plagues this area of southern California. Similar to the United States national average, over 90% of households in Los Angeles have access to at least one car, with many residences possessing two or more personal vehicles (Uranga 2023). As such, the transportation sector accounts for the largest proportion of greenhouse gas emissions of any sector, responsible for almost 39% of emissions in 2022 (CARB 2023). On-road transportation is a key source of greenhouse gas emissions in Los Angeles county, with the bulk of the impact coming from combustion of gasoline and diesel, which fuel the vast majority of vehicles in LA and across the world. Other sectors such as industry (23% of LA county emissions) and agriculture (8% of emissions) are also significant in their environmental impact. However, the largest source category by far is transportation posing the greatest risk to the environment and to human health, and therefore requires specific attention in policymaking for climate change mitigation (CARB 2023). Quantifying and understanding this key source category of emissions is needed for environmental preservation as well as for the benefit of human health, especially since gasoline and diesel combustion releases a wide range of air pollutants, including carbon monoxide, nitrogen oxides, volatile organic compounds, and harmful particulate matter (Campbell et al. 2018). While air quality has actually improved since the mid-20th century in Los Angeles, the American Lung Association has rated the county and neighboring areas with an 'F' for particle

and ozone pollution, with the levels of air pollutants increasing residents' risk of lung damage, asthma, heart attacks, and varying types of cancer, as well as many other potential health concerns (Cheung 2022).

There are a few possible methods to decrease the impact of the transportation sector on the overall amount of greenhouse gas emissions from Los Angeles County. In particular, a shift toward adopting more electric, zero-emission vehicles and moving away from the tradition internal combustion engine has been a major focus in emission mitigation efforts over the past several years. There is also a possibility of increasing ethanol biofuel usage (this study focuses on E85), as the emissions from biofuel are significantly less than fossil fuels, and a shift toward biofuel usage has the added benefit of not requiring significantly updated infrastructure, like EV's would require. As one of the most polluted areas in the United States, Los Angeles has set forth a list of ambitious sustainable development goals outlined in their Green New Deal. Notably, this list includes targets like a zero-carbon energy grid by 2050, 100% of new light-duty vehicle sales to be zero-emission by 2035, 100% zero-emission vehicles on the road by 2050 and zero days of unhealthy air quality by 2025 (a goal that was missed by January) (LA Green New Deal, 2019). For the purposes of improving residential and environmental health, my objective is to create an inventory that could be used for monitoring the levels of emissions caused by transportation in LA County, as this highly populated area plays a critical role in the essential fight against the impacts of climate change, and the inventory would serve as a baseline to assess future mitigation possibilities.

This inventory study and mitigation analysis focuses on the adoption of zero-emission vehicles as the main mitigation opportunity, aiming to mimic the goals already set by the LA County government, and as this is seemingly the category with the largest mitigation potential, mostly due to scalability issues with widespread adoption of biofuel usage. The scope of this study, however, does not include the social and environmental impacts and possible extent of material extraction for an increasing volume of electric cars (MIT Climate Portal). The study is also not fully exhaustive in analyzing the impacts of the infrastructure change that will be necessary if LA County plans to move toward a fleet of electric vehicles. There are nearly 8 million cars registered in LA County, and it would be a costly process to provide the necessary level of public charging, along with installation and constant upkeep (DeLollis & Justice).

Methods
For the Greenhouse Gas Inventory:

This greenhouse gas inventory uses several customized R functions to estimate the emissions of multiple different greenhouse gases from on-road transportation in Los Angeles County. Gasoline and diesel combustion are estimated in terms of Gg CO_2 equivalent, as well as breaking down estimates into amounts of CO_2, CH_4, and N_2O individually. Emissions from E85 alternative fuel are also estimated based on the number of gallons sold in LA county in 2010, 2015, and 2020, and these emission estimates account for the process of ethanol production, from corn agriculture through combustion. Additionally, emissions from electric zero-emission

vehicles are estimated based on electricity generation. All categories are estimated in a 95% confidence interval assuming 10% uncertainty on vehicle numbers and gallons of fuel sold, and 25% uncertainty on previously calculated emission estimates for E85 electric vehicle use. This inventory for on-road transportation in Los Angeles County, California uses IPCC Tier 1 methods to estimate emissions and default emission factors and equations outlined by the IPCC 2006 Guidelines (IPCC, 2006). The following equation, which multiplies the amount of fuel sold (depending on fuel type) by the default emission factor (in kg/TJ), was used to estimate emissions from gasoline and diesel combustion, this equation:

$$\sum[\text{fuel sold} * \text{emission factor}]$$

where the amount of fuel sold (depending on fuel type) is multiplied by the default emission factor (in kg/TJ).

For gasoline and diesel combustion:

Carbon dioxide, methane, and nitrous oxide emissions were estimated using the aforementioned equation and default emission factors listed below in Tables 1 (Gasoline) and Table 2 (Diesel).

Table 1. Emission factors and uncertainty ranges for motor gasoline

Greenhouse Gas	Lower	Default	Upper
CO_2	67,500	69,300	73,000
CH_4	1.1	3.8	13
N_2O	1.9	5.7	17

Table 2. Emission factors and uncertainty ranges for diesel fuel

Greenhouse Gas	Lower	Default	Upper
CO_2	72,600	74,100	74,800
CH_4	1.6	3.9	9.5
N_2O	1.3	3.9	12

The emission factor ranges were used to construct triangle probability distribution functions in a probabilistic analysis, along with the amounts of fuel sold in the designated year

provided from the California Energy Commission. Probability distribution functions were assumed to have 10% uncertainty in the fuel amounts due to variability in available data, where values differed slightly depending on the source. A Monte Carlo uncertainty analysis using 10,000 iterations was conducted to assess error, deriving median emissions as well as the upper and lower quantiles. Emissions are estimated in Gigagrams CO_2 equivalent, as well as Gg CO_2, CH_4, and N_2O, and the analysis was conducted R Version 4.5.

For Electric Vehicles:

Data on the per vehicle emissions from electricity generation were derived from the U.S. Department of Energy with an assumed 25% uncertainty, where the data is normally distributed (U.S. D.O.E.). Larger uncertainty was used in this calculation due to the emissions estimate having been derived from a study on the whole United States, and with only one year of data, rather than having specific per vehicle emission estimates from each year in the time series (2010, 2015, 2020). Data regarding the number of vehicles was gathered from the California Energy commission, and 10% uncertainty was assumed for each year of data. Using the number of vehicles in each designated year and the estimated per vehicle emissions, a probabilistic Monte Carlo simulation was conducted simulating 10,000 replications of the vehicle numbers and emission statistics, and the final emission estimates were calculated in Gigagrams CO_2 equivalent. This analysis was conducted R version 4.4.

For Alternative Fuel (E85):

Similar to the calculation for electric vehicles, the function for E85 utilized emissions that had already been calculated from a life cycle of the ethanol fuel from corn crop production through fuel processing to combustion (Wang et al. 2012). Data on the number of gallons of fuel sold in LA county in each respective year were collected from the California Energy Commission (CEC 2023), and a Monte Carlo analysis was used to simulate 10,000 replicates of emissions levels for 2010, 2015, and 2020, and results were then converted into Gg CO_2 equivalent. Uncertainty of 10% was assumed on the amount of fuel sold, and 25% uncertainty was assumed on the emissions that had already been calculated (in g CO_2 equivalent/MJ) since I was unsure on the origins of the data used for these calculations and the methods used to calculate the estimates. It was also assumed that one gallon of E85 contains 97.5 MJ. The emissions are estimated in Gg CO_2 equivalent as the final product using R, Version 4.4.

For the Mitigation Analysis:

The mitigation analysis portion of the study focuses on widespread adoption of electric vehicles within LA County. Using emission estimates that were calculated during the inventory process using R, a business-as-usual emission extrapolation was performed for each of the four fuel types of interest (gasoline, diesel, E85, and EV's). As the initial inventory was performed using data from 2010, 2015, and 2020, the extrapolation estimates emissions in each category

every five years from 2025 to 2050, and this extrapolation was performed using R version 4.5. For gasoline and diesel, a linear model was used for the extrapolation. For EV's and E85 fuel, I did both a linear model and a non-linear model (using a quadratic equation) was used due to the growth displayed in these categories during the initial inventory. While the time series only shows estimates from three separate years, the trends in these categories appeared to grow at a much quicker rate than gasoline (which was decreasing overall), or diesel, so the non-linear model was useful in showing us how the emissions from these categories would likely change with no real adjustment to policy or practice from current trends. The models were created in R, and plots were created subsequently to provide a visual representation of the business-as-usual extrapolation.

For the mitigation scenario, the study attempts to mirror the goals set forth by the current LA County government, which includes an objective of reaching 100% of new light-duty vehicle sales to be zero-emission vehicles by the year 2035. LA County has the ultimate goal of their entire fleet being electric by 2050, but to be conservative for our analysis purposes, we extrapolated emissions data according to an estimate of 90% of the fleet being electric by 2050, assuming an average vehicle lifespan of roughly 12-15 years and allowing for vehicle owners who keep their cars longer than average, who own vintage internal combustion engine (ICE) vehicles, or who own new high-end ICE vehicles, since these categories will still be utilizing gasoline or diesel by 2050. To conduct the calculations, I used 2020 data on the number of vehicles in Los Angeles and the emissions data to approximate the efficiency of an electric car compared to an ICE vehicle by calculating the emissions of a single vehicle from both categories, deriving an efficiency factor of about 0.4, and incorporating 10% uncertainty due to the variable nature of this calculation after scaling emissions down to one vehicle per category, and the variability in efficiency between different vehicle types/brands.

After approximating efficiency, emissions were extrapolated to 2050 and plotted against the business-as-usual emissions to show the difference between emissions from the Los Angeles vehicle fleet in 2050 with no policy change, compared with a fleet made up of 90% electric vehicles (Figure 8). Emissions estimates were then converted from Gigagrams to metric tonnes CO_2 equivalent in order to calculate Emission Reduction Tonnes (ERTs) according to the standards of the American Carbon Registry (ACR), as well as a three-pronged additionality test and a risk assessment. Using the ACR protocol, I calculated the total risk score by adding values for potential management and governance risks to natural disaster risks. Using the formula listed below, we calculated the buffer pool for the ERTs based on these risk calculations. We added a 10% uncertainty to the buffer pool to accommodate for market leakage, and 20% uncertainty for overall variability in our models and extrapolation.

Results and Discussion
For the Greenhouse Gas Inventory:

Total emissions values in Los Angeles County across all categories were about 130,816 Gg CO_2 equivalent in 2010, 132,447 Gg CO_2eq. in 2015, and 124,850 Gg CO_2eq. in 2020 (Table 3). Gasoline and diesel are the largest emission categories responsible for on-road transportation emissions, with average emissions many times greater than those for E85 and electric vehicle use

Table 3. Emissions Calculation Results with 95% Confidence Interval from 2010-2020 in Gg CO_2eq.

Fuel Type	2010	2015	2020
Gasoline (Gg)	116,593.40	114,745.13	107,294.89
2.5% Gasoline (Gg)	104,258.53	102,605.80	95,943.75
97.5% Gasoline (Gg)	129,420.40	127,368.80	119,098.92
Diesel (Gg)	14,208.36	17,602.89	17,249.06
2.5% Diesel (Gg)	12,756.13	15,803.71	15,486.05
97.5% Diesel (Gg)	15,631.95	19,366.59	18,977.31
EV (Gg)	0.13	11.20	53.39
2.5% EV (Gg)	0.07	5.58	26.61
97.5% EV (Gg)	0.20	17.40	82.99
E85 (Gg)	14.58	87.39	254.07
2.5% E85 (Gg)	9.76	58.53	170.16
97.5% E85 (Gg)	16.99	101.87	296.17

The analysis revealed changes in emissions throughout the three years that were studied, with the vast majority of emissions coming from gasoline combustion (Figure 1). For gasoline combustion, the amount of emissions was 116,593 Gg CO_2 equivalent in 2010, with a range from 104,258 to 129,420 Gg CO_2eq. according to the 95% confidence interval. In 2015, emissions from gasoline were 114,745 Gg CO_2eq., with a range from 102,605 to 127,368 Gg CO_2eq. In 2020, emissions from gasoline were 107,294 Gg CO_2eq., ranging from 95,943 to 119,098 Gg CO_2eq.
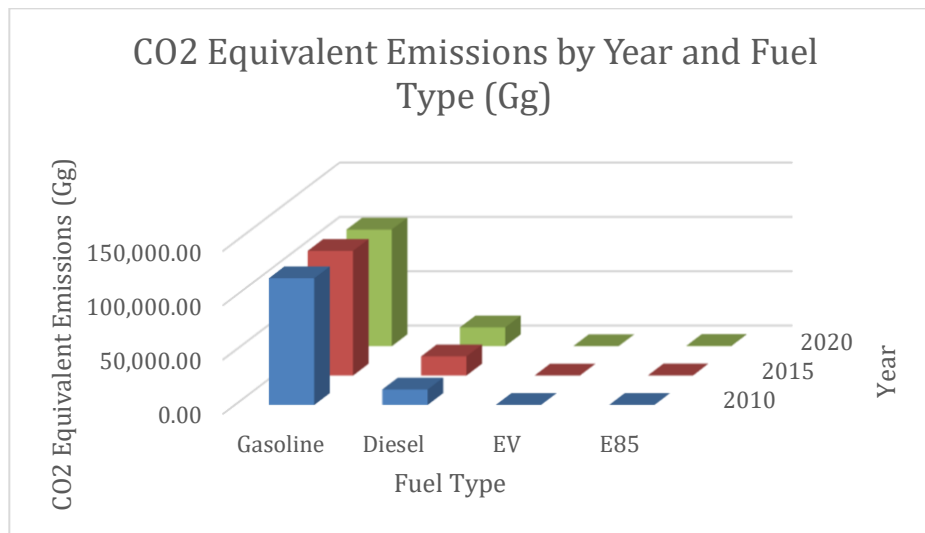
Figure 1. Mean CO_2eq. Emissions for Gasoline, Diesel, EV, and E85

Diesel combustion was the second largest source category for emissions from 2010 to 2020. In 2010, emissions from diesel were 14,208 Gg CO_2eq., ranging from 12,756 to 15,631.95 Gg CO_2eq. according to the 95% confidence interval. In 2015, emissions ranged from 15,803.71 to 19,367 Gg CO_2eq., with an estimated emission of 17,603 Gg CO_2eq. Finally, in 2020, diesel emissions ranged from 15,486 Gg CO_2eq. on the lower end to 18,977 on the upper end, with an estimated emission of 17,249 Gg CO_2eq.

Emissions from electric vehicles were calculated based on the electricity generated in the region from the California Energy Commission for the power grid for Los Angeles. In 2010, emissions from EV's ranged from 0.07 to 0.20 Gg CO_2eq., with an estimated emission of 0.13 Gg CO_2eq. In 2015, EV emissions were 11.20, with a range from 5.58 to 17.40 Gg CO_2eq. For 2020, emissions from EV's were 53.39, with a range from 26.61 to 82.99 Gg CO_2eq.

The emissions from E85 alternative fuel increased significantly from 2010 to 2020, showing an increase in usage of ethanol-based biofuels. In 2010, E85 use caused about 14.58 Gg CO_2eq. emissions. For 2015, the E85 emission as 87.39 Gg CO_2eq., and 254.07 Gg CO_2eq. for 2020, showing an increase of about 18x above the 2010 value.

There are carbon dioxide, methane, and nitrous oxide emissions from fuel combustion, and carbon dioxide was by far the most abundant greenhouse gas, for both gasoline and diesel (Table 4). The scope of this study does not include calculating individual greenhouse gas emissions for EV's or E85 use.

Table 4. Greenhouse gas emissions from gasoline and diesel for 2010, 2015, and 2020

GHG	2010	2015	2020	Key:
CO2 (Gg)	112,797.09	111,009.00	103,801.35	Gasoline
2.5% CO2 (Gg)	101,143.91	99,540.55	93,077.52	
97.5% CO2 (Gg)	124,912.32	122,932.18	114,950.36	
CH4 (Gg)	9.68	9.52	8.91	
2.5% CH4 (Gg)	3.31	3.26	3.05	
97.5% CH4 (Gg)	18.48	18.19	17.01	
N2O (Gg)	13.30	13.09	12.24	
2.5% N2O (Gg)	4.91	4.83	4.52	
97.5% N2O (Gg)	24.40	24.02	22.46	
CO2eq (Gg)	116,593.40	114,745.13	107,294.89	
CO2 (Gg)	13,896.44	17,216.45	16,870.39	Diesel
2.5% CO2 (Gg)	12,486.22	15,469.31	15,158.37	
97.5% CO2 (Gg)	15,268.56	18,916.38	18,536.15	
CH4 (Gg)	0.93	1.16	1.13	
2.5% CH4 (Gg)	0.42	0.52	0.51	
97.5% CH4 (Gg)	1.60	1.98	1.94	
N2O (Gg)	1.08	1.34	1.31	
2.5% N2O (Gg)	0.40	0.49	0.48	
97.5% N2O (Gg)	1.98	2.45	2.40	
CO2eq (Gg)	14,208.36	17,602.89	17,249.06	

Out of the four categories (gasoline, diesel, EV, and E85), gasoline was the only fuel type that showed a decrease in usage and emissions from 2010-2020, with emissions dropping by 9,298 CO_2eq. during the 10-year period (Figure 2). While part of this decrease in 2020 may have been due to the shift in transportation caused by the COVID-19 pandemic, data has shown that gasoline usage is dropping, despite more cars in Los Angeles (Reichmuth, 2024). Car ownership rates have stayed high, but there is a clear increasing trend in the number of EV's in LA county, which is promising when considering the goal in the LA Green New Deal to move to 100% EV by 2050. According to the California Energy Commission, in 2010 there were 207 all-electric vehicles on the road in Los Angeles county, but the fleet increased to 84,760 in 2020, representing an increase of 400x in just a decade. Previous inventory data from both Los Angeles county and the City of Los Angeles show the decreasing trend in transportation emissions, though the previous data collected shows lower emissions than the data collected in the current study. In contrast to the large increase in EVs, there was a drastic reduction in gasoline combustion emissions, and diesel combustion category increased significantly between 2010 and 2015, and then started to decrease through the next five year increment (Figure 2).
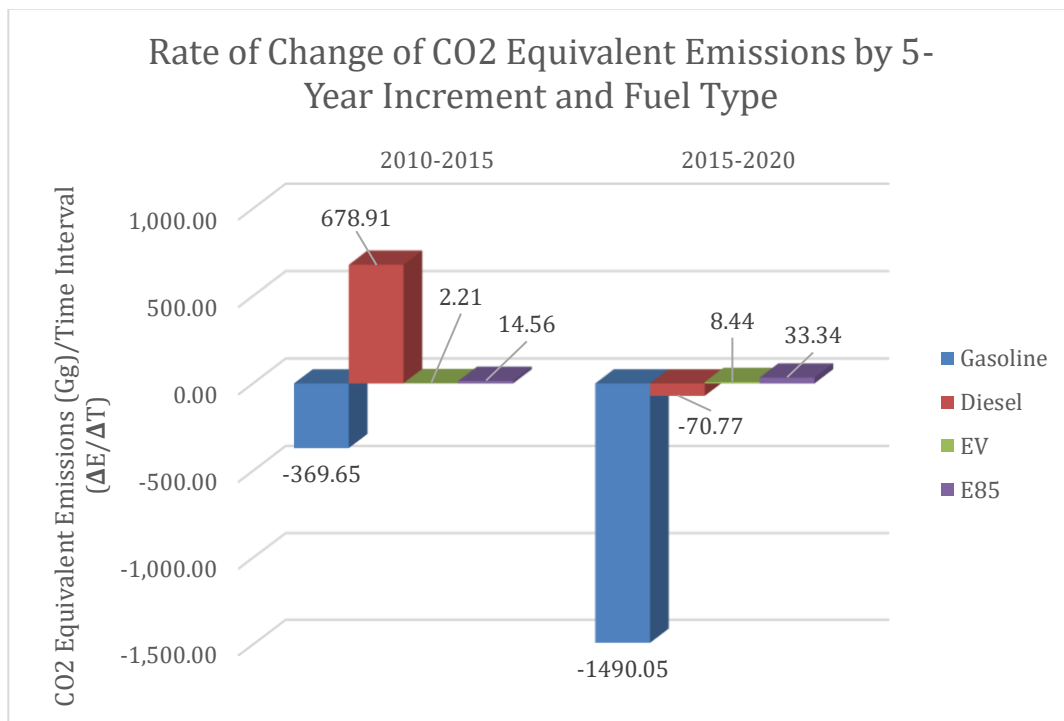

Figure 2. Rate of Change in GHG Emissions from 2010 to 2015 and 2015 to 2020

For the Mitigation Analysis:

From our business-as-usual extrapolations, we found that by 2050 emissions from gasoline should decrease to 80,330.83 Gg CO_2eq. based on current trends, diesel emissions will theoretically increase to 26,966 Gg CO_2eq. Emissions from electric vehicles are projected to increase to 960.05 Gg CO_2eq., and E85 emissions will also increase, reaching 3.225.42 Gg CO_2eq. in 2050 (Table 5).

Table 5. Extrapolated Emissions by Fuel Type (Gg CO_2eq.)

Extrapolated Emissions by Fuel Type (Gg CO2eq.)				
	Gasoline	Diesel	EV	E85
2025	103578.33	19394.33	126.7	514.62
2030	98928.83	20914.83	231.13	869.04
2035	94279.33	22435.33	366.68	1317.33
2040	89629.83	23955.83	533.35	1859.49
2045	84980.33	25476.33	731.14	2495.52
2050	80330.83	26996.83	960.05	3225.42

Gasoline was the only fuel type that shows a decreasing trend, though this is likely because LA County has already been shifting away from gasoline in favor of zero-emission vehicles, and our extrapolation just shows this trend continuing through to 2050. Emissions from diesel, E85, and EVs will all increase according to our business-as-usual projections, shown in Figures 3-6. Overall emissions in 2050 across all categories would come to 111,513 Gg CO_2eq.

With our mitigation scenario incorporating a fleet of 90% zero-emission vehicles, by 2050 the projected emissions would be 15,993 Gg CO_2eq., showing an emission reduction of 99,518 Gg CO_2eq. Overall ERTs come to 95,517,867 tonnes CO_2eq., or a very significant 85.7% reduction (Figure 8). Adjusting this value based on our risk assessment (20% reduction), uncertainty (20% reduction), and leakage (10% reduction), our final ERT value is 47,758,933.5 tonnes CO2eq.
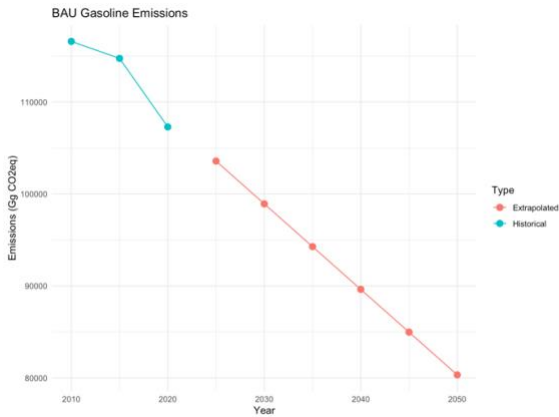
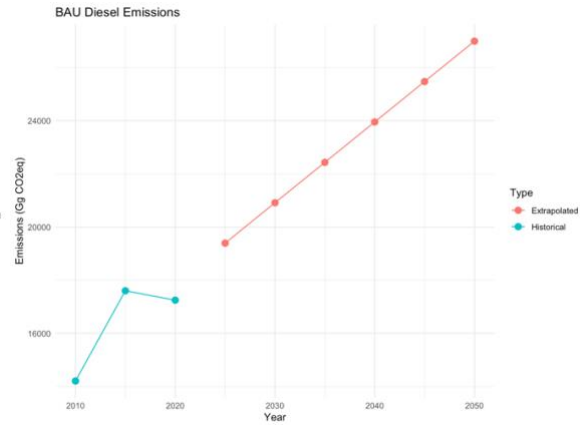Figure 3. Business-as-usual Gasoline Emissions

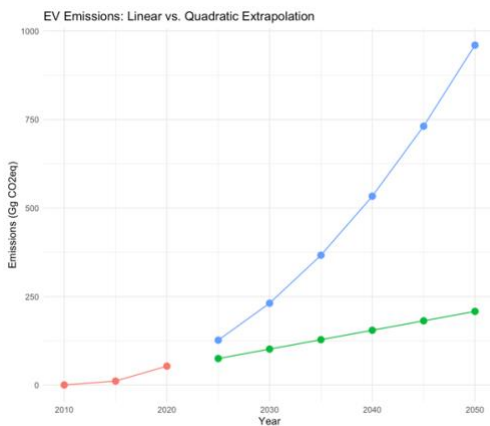Figure 4. Business-as-usual Diesel Emissions

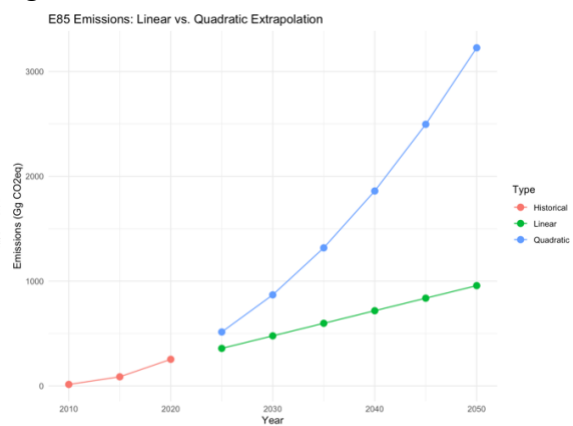Figure 5. Business-as-usual EV Emissions

Figure 6. Business-as-usual E85 Emissions

Because gasoline was by far the most abundantly used fuel type during the inventory time series, its decreasing trend shows how emissions would likely behave overall in a business-as-usual scenario (Figure 7). As the most widely used fuel type, gasoline drives trends in emissions, and our mitigation scenario is aimed at nearly eradicating the need for gasoline in Los Angeles County. This would ramp up the emissions from electric vehicles, as the electricity generation needed to power EVs would have to dramatically increase to accommodate the new market, so while Figure 7 shows the emissions increase in our business-as-usual model as very modest, these emissions would likely increase much quicker in our mitigation scenario, which is part of the reason for incorporating 20% uncertainty in our estimates, and the efforts to approximate efficiency of EVs compared with ICE vehicles.
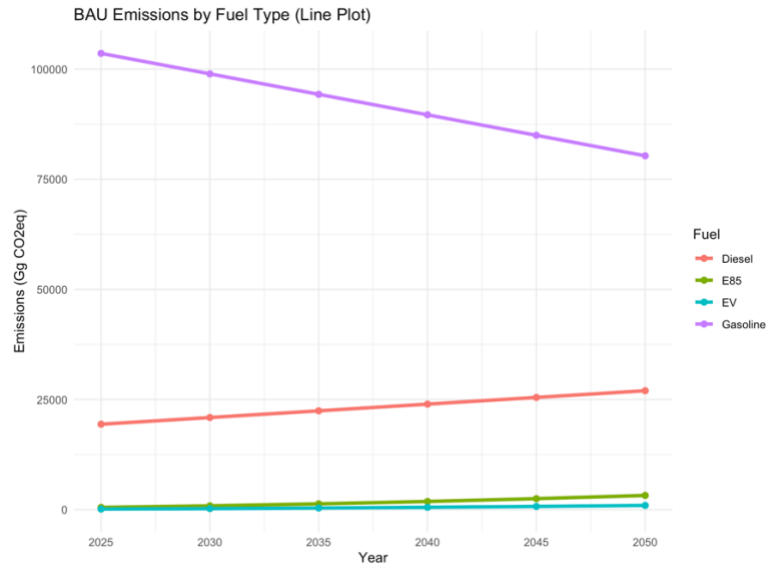
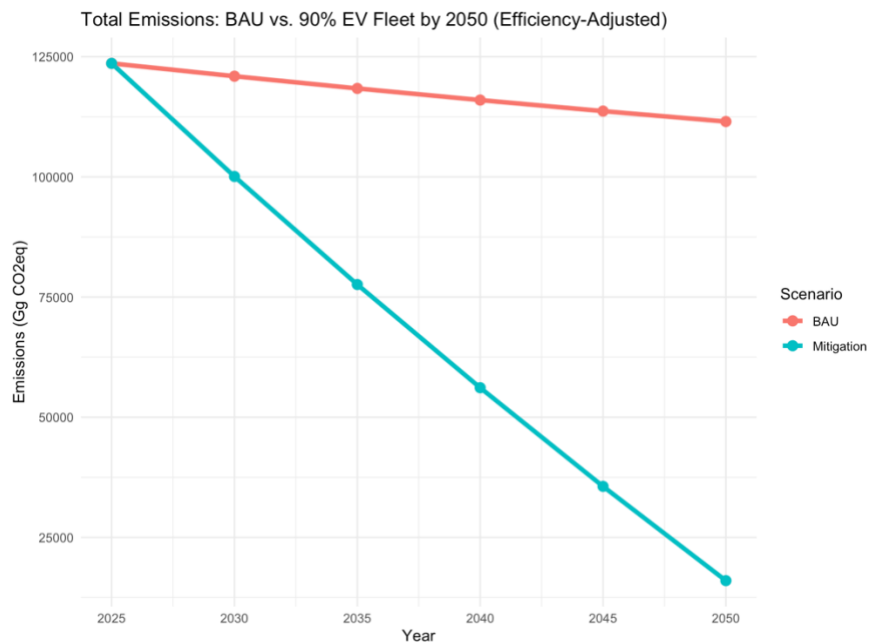Figure 7. CO₂eq. Emissions by Fuel Type, 2025-2050

Figure 8. CO₂ Equivalent Emissions, Business-as-usual vs. Mitigation, 2025-2050

We assumed a 10% ERT discount for leakage due to the likely impact that shifting to a fleet of almost entirely electric vehicles would have on gas prices in the area as demand for gasoline would drop significantly. This could create a negative environmental impact, as less gasoline used in LA might end up being used elsewhere, where there are fewer restrictions on transportation, and the cheaper prices might encourage gasoline users to drive more than they

normally would, therefore increasing emissions and fuel use in an unexpected area (Wei et al., 2025).

For this mitigation analysis scenario, we decided not to incorporate expanded use of E85 biofuel for a few reasons. The first reason is that while E85 is certainly more environmentally friendly than fossil fuels as it comes from a renewable resource and create fewer greenhouse gas emissions overall, it does still create tailpipe emissions from transportation, so we opted to focus on electric, zero-emission vehicles for this particular analysis. Additionally, the U.S. Department of Energy asserts that the United States uses an enormous amount of fuel, and the land use change required to shift to using E85 would have many negative environmental impacts, including the release of a significant amount of greenhouse gases. Using this much corn for fuel purposes would also create economic leakage which could interfere with the food system, as corn that would have been utilized for livestock under normal circumstances might now be repurposed. Lastly, E85 holds less energy than gasoline, so vehicles would be less fuel efficient, and these biofuels still have some of the same negative impacts as fossil fuels (like air pollutants) (Sarisky-Reed, 2022).

Appendix

This inventory and mitigation analysis, while attempting to quantify emissions from multiple source categories regarding on-road transportation in LA county and identify an avenue for significantly reducing emissions, made numerous assumptions which make accuracy difficult to verify. For the calculations for EV and E85 emissions, emissions data that had already been collected was utilized. The data available showed emissions per electric vehicle, and this number was applied to the calculations across all three years, so it does not account for any changes in efficiency through the years from 2010-2020. Similarly, data collected on E85 fuel production showed emissions in g CO_2eq./MJ, so I used this number (converted to demonstrate energy per gallon of fuel) across each year in the study. Since these emissions estimates were not specific to each year in the study, a higher level of uncertainty was assumed for the calculations– 25% to attempt to account for this lack of data. The approximation of EV efficiency was also quite variable and does not account for further technological developments as we approach 2050. Additionally, the scope of the mitigation analysis did not address resource extraction for materials needed for EVs, and did not account for emissions and expenses from adapting to the greater need for charging infrastructure. While we incorporated a large uncertainty percentage into the ERT calculation, I still feel that these factors most likely led to inaccuracies in our projections.

This lack of data led to other gaps in the findings of the study, particularly in that it was impossible to calculate estimates for emissions of individual greenhouse gases for the EV and E85 categories. Because the data used in the calculations was already showing CO_2 equivalent emissions, differentiating between individual gases was not a possibility.

Quality control measures included verifying unit conversions and cross-comparing results with previously conducted inventories. For these cross-comparisons, however, it was difficult to

determine if the results from the current study are consistent with previous reports, since the scope is often different in what sources are included. Additionally, it was difficult to find resources relating to all of Los Angeles County, rather than just within the LA city limits. For the mitigation analysis, checking to see if extrapolated values were within expected bounds was necessary, and done to the best of my ability but without extensive knowledge on the topic. I also initially didn't scale mitigation emissions based on EV efficiency, so the values came out the same as the business-as-usual scenario, and this was why I ended up adjusting the projection based on a vehicle efficiency factor. Documenting changes made to my code and keeping track of mistakes was also a way of attempting to derive the most accurate possible estimates.

References

Bishop, G. A. (2019). Three decades of on-road mobile source emissions reductions in South Los

Angeles. *Journal of the Air & Waste Management Association, 69(8), 967-976.* https://doi.org/10.1080/10962247.2019.1611677

California Energy Commission. (n.d.). Light-duty vehicle population in California.

https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics-collection/light?utm_source=chatgpt.com

Campbell, P., Zhang, Y., Yan, F., Lu, Z., & Streets, D. (2018). Impacts of transportation sector

emissions on future U.S. air quality in a changing climate. part II: Air quality projections and the interplay between emissions and climate change. *Environmental Pollution*, *238*, 918–930. https://doi.org/10.1016/j.envpol.2018.03.016

Cheung, J. (2022, March 25). *Air pollution in Los Angeles*. Earth.Org.

https://earth.org/air-pollution-in-los-angeles/

City of L.A. sustainable development goals. HOME | City of L.A. Sustainable Development

Goals. (n.d.). https://sdg.lacity.gov/

Current California GHG Emission Inventory Data. (n.d.).

https://ww2.arb.ca.gov/ghg-inventory-data

DeLollis, B., & Justice, G. (n.d.). The state of EV charging in America: Harvard research shows

Chargers 78% reliable and pricing like the "wild west": Institute for Business in Global
Society. Harvard Business School. https://www.hbs.edu/bigs/the-state-of-ev-charging-in-
america

Gallivan, F., Ang-Olson, J., Liban, C. B., & Kusumoto, A. (2011). Cost-effective approaches to

reduce greenhouse gas emissions through public transportation in Los Angeles,
California. *Transportation Research Record: Journal of the Transportation Research
Board*, *2217*(1), 19–29. https://doi.org/10.3141/2217-03

How is lithium mined? MIT Climate Portal. (2024, February 12).

https://climate.mit.edu/ask-mit/how-lithium-mined

Intergovernmental Panel on Climate Change. (2006). 2006 IPCC guidelines for national

greenhouse gas inventories (Vols. 1–5). Institute for Global Environmental Strategies.
https://www.ipcc-nggip.iges.or.jp/public/2006gl/

Parrish, D.D., Xu, J., Croes, B. *et al.* Air quality improvement in Los Angeles—perspectives for

developing cities. *Front. Environ. Sci. Eng.* 10, 11 (2016).
https://doi.org/10.1007/s11783-016-0859-5

Reichmuth, D., (2025, February 25). *Has gasoline use in California peaked?*. The Equation.

https://blog.ucs.org/dave-reichmuth/has-gasoline-use-in-california-peaked/

Sarisky-Reed, V. (2022, June 23). Ethanol vs. petroleum-based fuel carbon emissions.

Energy.gov. https://www.energy.gov/eere/bioenergy/articles/ethanol-vs-petroleum-based-
fuel-carbon-emissions

Uranga, R. (2023, August 16). *Going car-less in L.A.: The environmental benefits and economic*

costs. Los Angeles Times. https://www.latimes.com/california/story/2023-08-16/car-less-
angelenos-share-their-secrets

Vehicles registered by County. California DMV. (2022, May 27).

> https://www.dmv.ca.gov/portal/dmv-research-reports/research-development-data-
> dashboards/vehicles-registered-by-county/

Veza, I., Asy'ari, M. Z., Idris, M., Epin, V., Rizwanul Fattah, I. M., & Spraggon, M. (2023a).

> Electric vehicle (EV) and driving towards sustainability: Comparison between EV, HEV,
> PHEV, and ice vehicles to achieve net zero emissions by 2050 from ev. *Alexandria
> Engineering Journal*, *82*, 459–467. https://doi.org/10.1016/j.aej.2023.10.020

Wachs, M. Learning from Los Angeles: transport, urban form, and air quality. *Transportation*
> 20, 29–354 (1993). https://doi.org/10.1007/BF01100463

Wang, M., Han, J., Dunn, J. B., Cai, H., & Elgowainy, A. (2012). Well-to-wheels energy use and

> greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for us
> use. *Environmental Research Letters*, *7*(4), 045905. https://doi.org/10.1088/1748-
> 9326/7/4/045905

Wei, F., Walls, W. D., & Zheng, X. (2025). Fuel efficiency, power trading, and emissions

> leakage from driving electric vehicles: Evidence from Chinese provinces. Energy Policy,
> 198, 114473. https://doi.org/10.1016/j.enpol.2024.114473