Reducing Carbon Emissions by Eliminating Gas-Powered Vehicles in Highly Populated States: An Environmental and Economic Analysis

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I. Introduction

The United States of America is made up of fifty states all the way from Maine, to Alaska, to Hawaii. It may be odd to imagine that merely four states utilize over 30% of the nation's fuel usage for transportation [1]. California, Florida, New York, and Texas are some of the most well-known states today; coincidentally, they are also the home to many of our largely populated cities today: Los Angeles, Jacksonville, New York City, Houston, and more.

The impact of climate change on today's community is unparalleled as it is one of the most pressing issues facing humankind. Climate change refers to the variation in temperatures and weather patterns caused predominantly by human activities. This ubiquitous issue has caused harm to beings of multiple species through food, water, and shelter availability. Cars, and other modes of transportation, take up roughly 27% of the total carbon emissions, the fumes released when burning fossil fuels, in the United States [2]. The number of cars driven today is more significant than ever; the amount of carbon emissions produced by these cars is greater than ever. The role transportation plays in our country's carbon emissions continues to be distinctly substantial

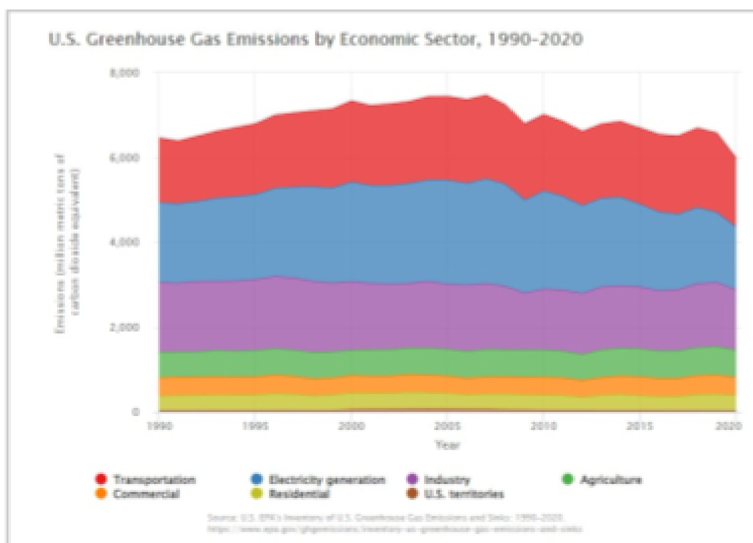

Figure 1. Shows transportation's contribution in America's overall greenhouse gases
Adapted from United States Environmental Protection Agency: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

as shown in Figure 1. The work and research presented seek to address rational solutions to minimize the United States' contribution to climate change. By reducing the number of carbon emissions released by gasoline-powered vehicles on the road, we hope to purify the air we breathe; these gas cars will be replaced with other modes of transportation based on the state's unique transportation infrastructure.

It is understood that these four states have very different communities compared to one another. With California being the frontrunner in moving towards fully electric vehicles, it can be concluded that this should remain their primary goal for the betterment of the people. As of 2035, California has proposed to ban the sale of all new gas-powered cars [3]. Evidently, the future of transportation in this state is electric vehicles.

Keeping Texas's terrain and size in mind, it would be difficult to envision any public transportation being capable of providing an efficient system for everyone. Therefore, it is believed that electric vehicles would result in the most considerable progress in Texas.

As New York is rather known for its remarkable train and subway system framework; the transportation availability provided to the state's residents is like no other. With subways being fully electric today, this type of public transportation can aid in working towards a healthier New York.

With Florida's beautiful weather and friendly outdoors, outdoor transportation such as walking and biking are more climate-friendly options that suit the state's population. Otherwise, Florida's bus system is a rather popular and effective way to control the carbon emissions released into the air.

Our projected results demonstrate that, alongside specific methods for specific areas in the country, the level of carbon emissions from high gas-consuming states will sufficiently decrease. These calculations will be performed using gas costs (different per state), vehicle pricing and mileage, and other fixed expenses (different per scenario). In each of the four scenarios, we remove 50% of the gas cars on the road and replace them with more environmentally and financially efficient options.

II. California

Proposed in the past two years, California plans to end all gasoline-powered vehicle sales by 2035. With a heavy belief in minimizing carbon emissions produced by vehicle transportation, California will likely become one of the first states to fully electrify transportation. As seen in Table 2, as of 2020, the cars of California have used over eleven billion gallons of fuel and emitted over a hundred billion kilograms of carbon dioxide [4,5,6,7]. Driving roughly

GALLONS	ANNUAL CO2 OUTPUT (kg)
11,478,138,000.00	102,006,212,406.00

Table 2. Comparing current California's total gasoline usage to the total carbon dioxide output (kg)

eighteen thousand miles on average every year, every vehicle in California manages to release over seven thousand kilograms of carbon dioxide annually. Electric vehicles have become an upcoming sensation that is continuously modernizing technology and helping the air we breathe. As electric cars do not utilize any version of gasoline, they do not produce any carbon

GALLONS	ANNUAL CO2 OUTPUT (kg)
5,739,069,000.00	51,003,106,203.00

Table 3. Comparing California's prospective total gasoline usage to the total carbon dioxide output (kg)

emissions. In the potential solution presented in this work, a fraction of gasoline-powered cars is taken off the roads and replaced with electric vehicles. Through this, the total carbon dioxide output for California will be approximately cut in half along with the total number of gallons consumed; this is shown in Table 3.

The cost of an electric car is unsurprisingly higher than one of a gasoline-powered car; this price difference is roughly $10,000 [8]. However, over ten years, our research projects that owning and operating an electric car will cost less than and be more economical than owning and operating a gas car. When driving a car powered by gasoline, one has to be able to afford the current high gas rates and pay a higher annual cost for maintenance. As electric vehicles are manufactured without an engine, their maintenance costs are far cheaper—roughly $330 less per year [9]. Although there is an electricity cost when charging an electric car, it is exceptionally cheaper than the cost of gas. The calculated average cost per mile in California for a gasoline-powered car is twenty-seven cents per mile, this is much more expensive compared to electricity which costs three cents per mile [10]. On top of this, our federal government gives a $7,500 rebate in taxes to those who have purchased an electric vehicle [11]. In our presented results, we presume that, since California promotes the concept of owning an EV, they would match the federal rebate with a $7,500 state rebate. Taking a look at Table 4, we see that in merely ten years, the average California resident purchasing an electric vehicle will begin to

GASOLINE-POWERED CAR		ELECTRIC VEHICLE	
COST PER MILE ($)	0.29	AVERAGE COST OF EV ($)	56,437.00
COST PER GALLON (S)	6.29	FEDERAL REBATE ($)	7,500.00
ANNUAL GAS COST (S)	5,135.16	STATE REBATE ($)	7,500.00
MONTHLY MAINTENANCE ($)	98.83	ANNUAL ELECTRICITY ($)	538.82
ANNUAL MAINTENANCE (S)	1,186.00	ANNUAL MAINTENANCE ($)	856.00
GAS CAR OVER TEN YEARS ($)	63,211.60	EV OVER TEN YEARS ($)	55,385.24
MONEY SAVED ($)			**7,826.36**

Table 4. Comparing California's prospective total gas car cost to the total electric vehicle cost (10 year span)

save money. Through 50% of California's driving population converting to electric cars, the whole state will cut its transportation carbon emissions in half, and the residents of the state will save money; undoubtedly, this solution will benefit both the people of California and its environment.

III. Texas

In parallel, it is believed that those from Texas would also benefit from a similar method. As Texas currently holds the spot for the second largest state at roughly 270,000 square miles, it is not the easiest to travel from one side to the other [12]. The ease at which one may find public transport in New York will not be the same in Texas. It would be impractical to assume that there would be readily available public transport for those who wish to travel long distances within the state. For these reasons, it is assumed that Texas would be most benefited if they follow in California's footsteps.

STATE	TOTAL GALLONS	TOTAL GAS CARS	ANNUAL GALLONS PER CAR	ANNUAL MILES PER CAR	ANNUAL CO2 OUTPUT (kg)
California	11,478,138,000.00	14,059,386.00	816.40	17,960.80	102,006,212,406.00
Texas	12,264,546,000.00	8,007,177.42	1,531.69	33,697.18	108,995,020,302.00

Table 5. Comparing Texas to California's annual gallons per car

Although Texas does not have nearly as many gas cars as California, these cars use almost a billion more gallons in total compared to California's transportation. As seen in Table 5, every car in Texas drives roughly double as many miles in a year. This makes sense as people in Texas are traveling more miles yearly due to the size of the state and the availability of public transport. Even though the gas prices in Texas are cheaper by almost $2 per gallon, fuel costs are over $1,000 more expensive per year per car than in California [13]. The advantage of going half electric in Texas is that it will increase the residents' savings after ten years. Since Texas cars are driving more miles in an average year, they will continue to save more as the cost of electricity per mile is nearly one-seventh that of gas per mile. With a proposed plan identical to that of California, our results show even larger savings to the consumer and a similar reduction in carbon emissions; Table 6 shows Texas's proposed gallon usage and carbon output if half of

	GALLONS	ANNUAL CO2 OUTPUT (kg)
CURRENT	12,264,546,000.00	108,995,020,302.00
PROPOSED	6,132,273,000.00	54,497,510,151.00

Table 6. Comparing current and proposed Texas's total gasoline usage to the total carbon dioxide output (kg)

the gasoline cars are replaced with electric cars. Since Texas releases more carbon emissions than California, when we cut that number in half, we are cutting out more carbon emissions compared to California on a kilogram basis.

Below, in Table 7, are the financial benefits linked to purchasing an electric vehicle in Texas. Clearly, we see that the Texas residents owning a gasoline-powered car will benefit more than those in California by over $10,000. Through the research presented, one can confidently claim that purchasing an electric vehicle in Texas will benefit both the climate and consumers' pockets.

GASOLINE-POWERED CAR		ELECTRIC VEHICLE	
COST PER MILE ($)	0.20	AVERAGE COST OF EV ($)	56,437.00
COST PER GALLON (S)	4.49	FEDERAL REBATE ($)	7,500.00
ANNUAL GAS COST (S)	6,877.29	STATE REBATE ($)	7,500.00
MONTHLY MAINTENANCE (S)	98.83	ANNUAL ELECTRICITY ($)	1,010.92
ANNUAL MAINTENANCE (S)	1,186.00	ANNUAL MAINTENANCE (S)	856.00
GAS CAR OVER TEN YEARS ($)	78,260.90	EV OVER TEN YEARS ($)	60,106.15
	MONEY SAVED ($)		**18,154.75**

Table 7. Comparing Texas's prospective total gas car cost to the total electric vehicle cost (10 year span)

IV. New York

When comparing New York to Texas, the environments of these two states are opposite. On one hand, Texas is very spread out and is considered one of the more rural parts of our country; on the contrary, New York can be seen as very suffocating. Although the northern half of New York tends to be mostly rural, the Boroughs of New York City (Bronx, Brooklyn, Manhattan, Queens, and Staten Island) are crowded enough to make the state one of the most densely populated places in the United States [14]. Considering the heavy traffic and city life in this state, adding more electric vehicles will not benefit New York as much as California and Texas. New York's train and subway network maps throughout the state like no other; its advanced railway lines help people get from one location to another every day. New York's train and subway lines run on electricity and do not utilize any sort of gas or fossil fuels [15]. Keeping the heavy traffic flow in mind, it would be cheaper and more efficient to take a subway or train instead.

	GALLONS	ANNUAL CO2 OUTPUT (kg)
CURRENT	4,481,526,000.00	39,827,321,562.00
PROPOSED	2,240,763,000.00	19,913,660,781.00

Table 8. Comparing current and proposed New York's total gasoline usage to the total carbon dioxide output (kg)

Above in Table 8, we are shown that the overall gallon usage and carbon dioxide output is cut in half when the number of gas cars on the roads is similarly reduced.

GASOLINE-POWERED CAR		SUBWAY/TRAIN	
ANNUAL GAS COST (S)	5,272.49	MONTHLY COST OF TRANSIT CARD ($)	127.00
ANNUAL MAINTENANCE (S)	1,186.00	ANNUAL COST OF TRANSIT CARD ($)	1,524.00
GAS CAR OVER TEN YEARS ($)	64,584.90	SUBWAY/TRAIN OVER TEN YEARS ($)	15,240.00
	MONEY SAVED ($)		**49,344.90**

Table 9. Comparing New York's prospective total gas car cost to the total subway/train cost (10 year span)

Similar to Texas and California, when switching half of New York to more environmentally-friendly options, residents of New York would also financially benefit. Comparing the price that people would pay for gas, train and/or subway tickets comes out to be a much cheaper alternative. In Table 9, we exhibit larger savings than the previous electric vehicle solutions for California and Texas. A transit card is a fixed monthly expense, and this card will cover all train and subway expenses throughout New York. Although a train or subway may not cover all the travel that a consumer may need, the savings are large enough that the consumer does not need to worry about spending more money than he or she would when driving a gasoline-powered car. Therefore, even when taking into consideration that subways/trains may not cover all transportation, New York residents will still come out ahead financially while the nature around us ameliorates.

V. Florida

The state of Florida can be considered as one very different from the rest. Being a state with one of the largest senior citizen populations—roughly 21%—Florida's chances of switching to electric vehicles seem realistically low [16]. Additionally, the state is not very well known for its train or subway system.

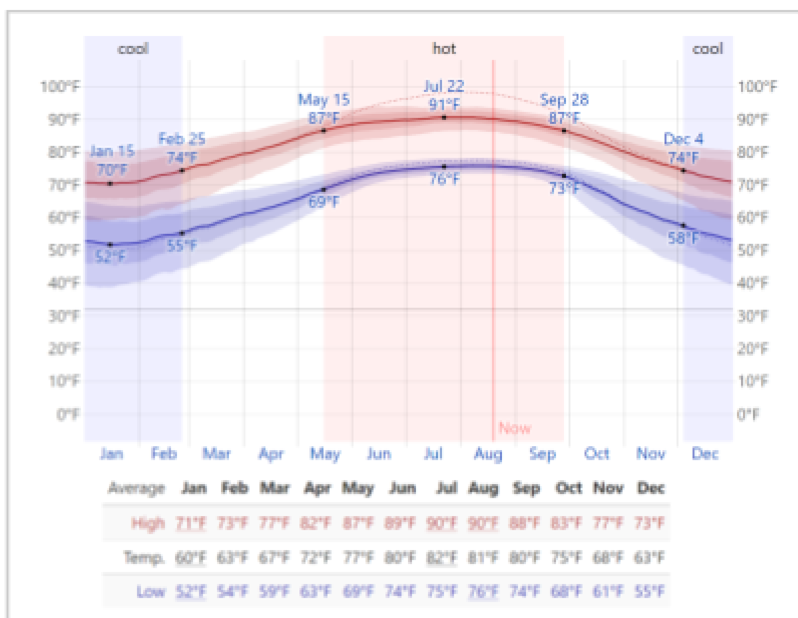

Figure 2. Shows the monthly average temperatures in Florida Adapted from Weather Spark: https://weatherspark.com/y/17721/Average-Weather-in-Orlando-Florida-United-States-Year-Round#Figures-Temperature

Residents of Florida highly benefit from its perennial, beautiful weather; this allows them to take advantage of the outdoors and use it for local transportation. This is displayed in Figure 2 where it is shown that the average temperature year-round does not drop below sixty degrees and does not rise above eighty-two degrees.

Florida, commonly known for its busing system, can implement more electric bus options alongside a greater population of bicyclists. Through 25% of Florida residents switching to electric buses and another 25% to bicycles, the state can eliminate half of the gasoline-originated carbon emissions; specific fuel usage in the current and proposed case as well as annual carbon dioxide output are shown in Table 10.

	GALLONS	ANNUAL CO2 OUTPUT (kg)
CURRENT	7,705,152,000.00	68,475,685,824.00
PROPOSED	3,852,576,000.00	34,237,842,912.00

Table 10. Comparing current and proposed Florida's total gasoline usage to the total carbon dioxide output (kg)

When comparing a bicycle to a bus pass, the price difference is evident. For example, the price of a durable and long-lasting bicycle is roughly $500 [17]. Even if one purchases a bicycle every five years, the expense over ten years would be only $1,000. On the other hand, we assume that an electric bus pass would be a monthly fee of roughly $57. A normal bus pass is currently $38 and we are assuming this monthly fee would increase by 150% to offset the costs of purchasing an electric bus fleet [18].

GASOLINE-POWERED CAR		BICYCLE	
ANNUAL GAS COST (S)	4,585.49	AVERAGE COST OF BICYCLE ($)	500.00
ANNUAL MAINTENANCE (S)	1,186.00	ADDITIONAL COSTS ($)	0.00
GAS CAR OVER TEN YEARS ($)	57,714.90	BICYCLE OVER TEN YEARS ($)	1,000.00
MONEY SAVED ($)			**56,714.90**

Table 11. Comparing Florida's prospective total gas car cost to the total bicycle cost (10 year span)

As seen in Table 11 and Table 12, when switching to either a bicycle or electric bus, the average

GASOLINE-POWERED CAR		ELECTRIC BUS	
ANNUAL GAS COST (S)	4,585.49	MONTHLY COST OF ELECTRIC BUS ($)	57.00
ANNUAL MAINTENANCE (S)	1,186.00	ANNUAL COST OF ELECTRIC BUS ($)	684.00
GAS CAR OVER TEN YEARS ($)	57,714.90	ELECTRIC BUS OVER TEN YEARS ($)	6,840.00
MONEY SAVED ($)			**50,874.90**

Table 12. Comparing Florida's prospective total gas car cost to the total electric bus cost (10 year span)

gas-car driver saves more than $56,000 in the bicycle scenario and more than $50,000 over ten years in the bus scenario. Similar to New York, there will be residents of Florida who may need to use other transportation options in certain situations. Even considering the cost of those transportation options (taxi, ferry, plane, and carpool), a Florida resident would be much better

BICYCLE		ELECTRIC BUS	
MONEY SAVED CURRENTLY ($)	56,714.90	MONEY SAVED CURRENTLY ($)	50,874.90
TAXI ($100 per month)	-12,000.00	TAXI ($100 per month)	-12,000.00
FERRY ($100 per month)	-12,000.00	FERRY ($100 per month)	-12,000.00
PLANE ($500 per year)	-5,000.00	PLANE ($500 per year)	-5,000.00
CARPOOL	-0.00	CARPOOL	-0.00
MONEY SAVED WITH OTHER COSTS ($)	**27,714.90**	**MONEY SAVED WITH OTHER COSTS ($)**	**21,874.90**

Table 13. Proving financial benefit to Florida's residents even with additional transportation options

off eliminating their gasoline-powered car usage; this is shown in Table 13. Once again, focusing on the environment and financial aspects, the average citizen benefits more by transitioning to more eco-friendly transportation alternatives.

VI. Discussion/Sensitivity Analysis

STATE	ASSUMPTION	NOMINAL VALUE	NEW VALUE	NOMINAL AVERAGE MONEY SAVED	MONEY SAVED IN ALTERNATE SCENARIO
California	Cost of Gas (per gallon)	$6.29	$5.00	**$7,826.36**	-$2,705.24
	State Rebate	$7,500.00	$0.00		$326.36
Texas	Cost of Gas (per gallon)	$4.49	$3.20	**$18,154.75**	-$1,604.05
	State Rebate	$7,500.00	$0.00		$10,654.75
New York	Cost of Gas (per gallon)	$4.93	$3.60	**$49,344.90**	$35,120.90
	Cost of Transit Card (per month)	$127.00	$250.00		$34,584.90
Florida	Cost of Gas (per gallon)	$4.62	$3.30	**BIKE: $56,714.90**	$40,693.50
	Cost of Bike (and purchase frequency)	$500.00 (2 times/10 years)	$650.00 (4 times/10 years)	**ELECTRIC BUS:**	$55,114.90
	Percent Difference of Electric Bus	150%	250%	**$50,874.90**	$46,314.90

Table 14. Shows change in assumptions and its effect on the outcome (money saved)

In the solutions presented throughout the paper, many assumptions are made that may change the results. For example, one commonality among all four solutions was the gas price per gallon used in the calculations. For each state, we assumed that the gas price would remain constant at the same value and not change for ten years. However, this is certainly not the case; gas prices tend to change almost every day with either an increase or decrease in dollar amounts. A sensitivity analysis was performed comparing the impact of different costs of goods and services, as well as the absence of the state rebate, on the average money saved; the results are presented in Table 14.

As seen in California and Texas, the prices of gas play a large role in whether one comes out ahead financially in ten years or not. But when looking at Florida and New York, the savings are much larger, so gas prices will not bring it down to below $0 saved.

Looking at how differently the state rebate impacts California and Texas, it is clear it will cause a large gap in the financial aspect. It would be highly beneficial for California residents but is not necessary for those living in Texas; the savings made in California is significantly lower compared to the one in Texas.

Moving on to New York, it is assumed that the gas price per gallon will remain consistent. However, even after inputting a much cheaper gas value, we see New York residents remain financially ahead in the long run. Moreover, we attempted to make the monthly cost for a transit card higher than before—roughly 200%—and concluded that even large changes in price will not affect the outcome that our research shows in the state of New York.

Florida, the Sunshine State, is very similar to New York in this way; the savings are already so large that the assumptions we made do not impact the final dollar amount. As done with the gas price in the three other states, decreasing Florida's gas price takes a toll on one's savings; however, they remain ahead by over $40,000. In addition, taking the individual solutions we provided for Florida—electric buses and bicycles—and increasing their prices does not impact one's savings. In both scenarios, we see that a resident of Florida still manages to save $45,000 even with assumptions made by our research.

VII. Conclusion

In 2020, our nation used over a hundred billion gallons of gasoline to power all transportation; this number increased in 2021, and one can assume it will do the same this year [19]. As shown in Figure 3, the amount of carbon emissions we continue to put into our air is escalating, and efforts to bring that number down have not made a significant impact in eliminating climate change. Our presented solution proves that bringing this number down may not be as difficult as one may perceive. Clearly shown in the figure, the US only plays a small role in worldwide CO_2 emissions. The role transportation plays in our country's carbon emissions continues to be distinctly substantial. Knowing that four U.S. states make up almost a third of our total gasoline usage, reducing the carbon emissions they produce by half can decrease the country's transportation carbon emissions by 15%. With this—ideas of implementing electric vehicles, trains/subways, electric buses, and bicycles—our efforts towards making our environment a cleaner place can genuinely prove to be effective. Not only will our surroundings benefit from this, but the residents of these states will also financially benefit as they will save money in the long run; by considering such a proposal, our nation will truly demonstrate its focus on the community and its future welfare.

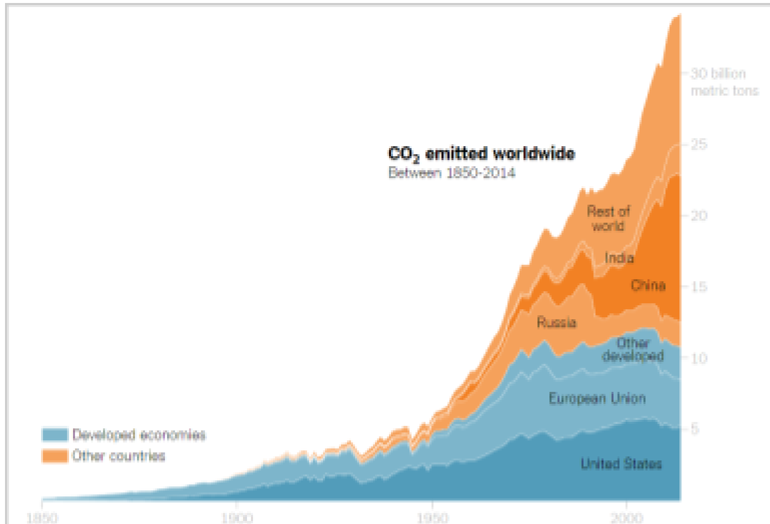

Figure 3. Shows the increase in carbon dioxide emissions worldwide (1850-2014)
Adapted from NY Times: https://www.nytimes.com/2019/02/28/learning/teach-about-climate-change-with-these-24-new-york-times-graphs.html

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Appendix

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