Introduction:

As global concerns regarding climate change and environmental sustainability continue to rise, reducing carbon dioxide (CO_2) emissions has become a critical focus for policymakers, researchers, and industries worldwide. One of the most significant contributors to CO_2 emissions is the transportation sector, particularly from the burning of fossil fuels in traditional vehicles. However, with the increasing adoption of electric vehicles (EVs), there is growing hope that this transition could significantly reduce the environmental impact of transportation. Electric vehicles are seen as a cleaner alternative, emitting little to no direct CO_2 during operation.

In this report, I aim to explore whether states in the United States with higher adoption rates of electric vehicles are experiencing a corresponding reduction in CO_2 emissions from the transportation sector. The focus is on determining if the widespread adoption of EVs is a key factor in reducing transportation-related emissions, which could be a crucial strategy for mitigating climate change.

This analysis is important not only for understanding the environmental impact of electric vehicles but also for informing future policies that could accelerate the transition to a more sustainable transportation system.

Data Overview

The analysis uses two datasets: CO_2 emissions data from the USA and vehicle data from Washington State. These datasets are combined to analyse the relationship between vehicle characteristics and CO_2 emissions. The data pipeline processes and cleans the data before storing it in a SQLite database for further analysis.

1. CO_2 Emissions USA Dataset:

The co2_usa dataset contains CO_2 emissions data for vehicles in the United States. It includes various columns such as fuel-name, value, and additional emissions-related information. After downloading the dataset, irrelevant columns and missing data are handled through various techniques, such as filling missing values based on mode grouping. The dataset is stored in the SQLite database under the table co2_usa.

2. Vehicle Data from Washington State:

The cars dataset contains detailed information about vehicles registered in Washington State. It includes columns such as Make, Model, Year, Electric Utility, Electric Range, and Base MSRP. Irrelevant columns are removed, and missing values are filled using mode grouping to maintain consistency across the dataset. Outliers in Base MSRP values are identified and corrected based on the mode for each Make and Model Year. This cleaned dataset is stored in the SQLite database under the table cars.

Data Pipeline Output:

The output of the data pipeline consists of two cleaned and pre-processed datasets: co2_usa and cars. These datasets are now ready for analysis, where relationships between vehicle attributes (e.g., Electric Utility, and CO_2 Emissions) and emission levels will be explored.

Licenses and Compliance

Each dataset is provided under specific licenses:

- **cars**: Open Database License (ODbL) v1.0, allowing free use, modification, and distribution with attribution and under the same license.
- **co2_usa**: Apache License 2.0, permitting free use and modifications with attribution.

To ensure compliance with these licenses, the datasets will be properly attributed, and modifications will be shared under the same license. A disclaimer will also be added for "as-is" use.

Analysis:

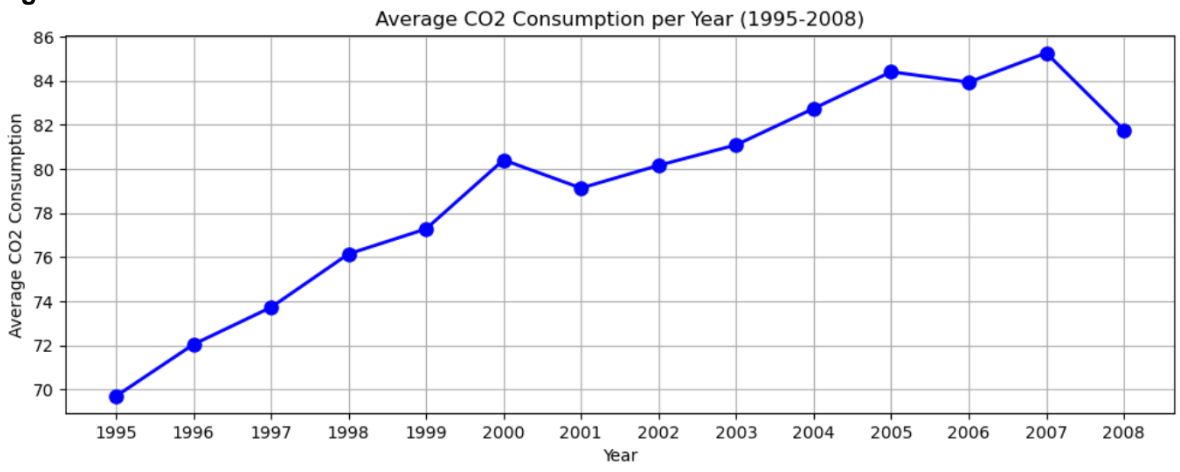
This section presents the executed analysis to address the research questions, detailing the methods, results, and interpretations of the findings.

The analysis of CO2 emissions data began by filtering for "Transportation Carbon Dioxide Emissions" and "Electric Power Carbon Dioxide Emissions," as these are the most relevant categories where electric vehicles (EVs) could have a significant impact. The focus was further narrowed to include only data for Washington State, allowing for an in-depth examination of how EV adoption has affected CO2 emissions in the region. The data was divided into two distinct periods: from 1995 to 2008, when EVs were not yet present, and from 2008 to 2021, when EV adoption began to emerge.

CO2 Emissions Increase from 1995 to 2008:

By examining **Figure 1**, we can observe the average CO2 emissions from 1995 to 2008. During this period, there was an annual increase at an average rate of 1.266 % per year, starting at 72 million metric tons in 1995 and reaching 85 million metric tons in 2007. However, emissions decreased in 2008 to 82 million metric tons, likely due to the 2008 economic crisis.

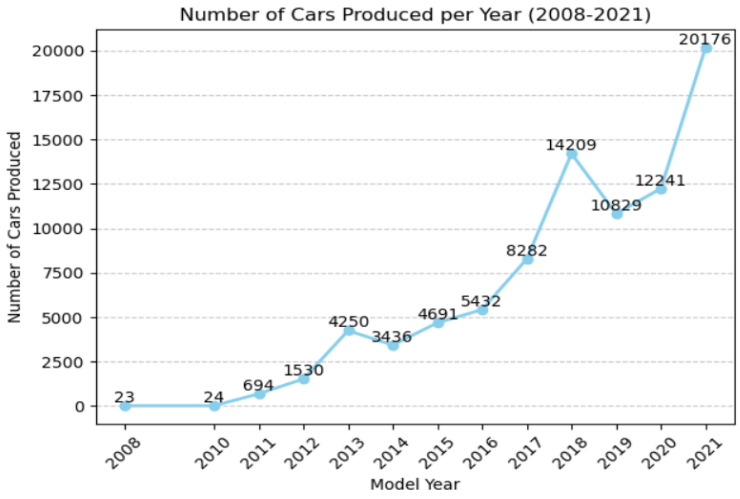
Figure 1



EV Growth:

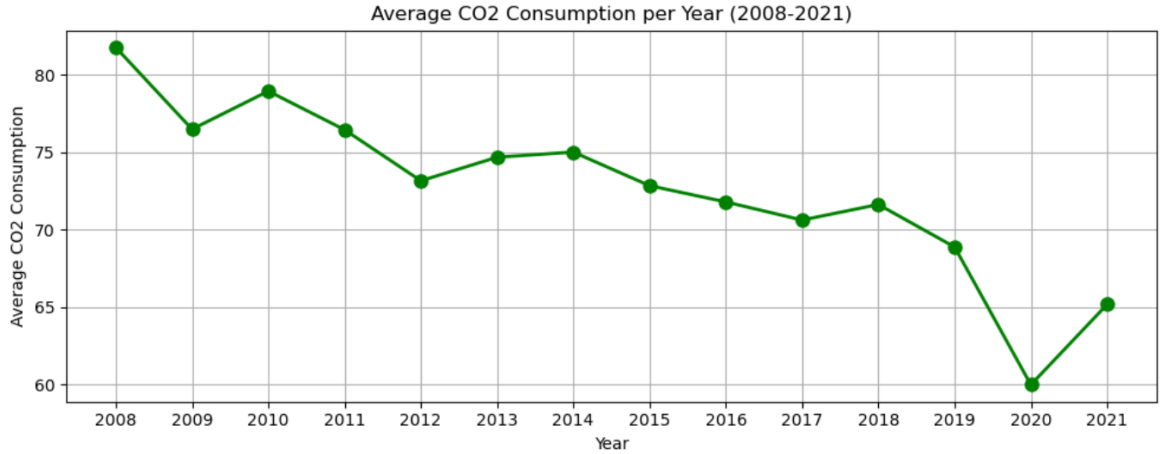
As shown in **Figure 2**, the data indicates a significant increase in electric vehicle (EV) production and adoption. Starting with only 23 EVs in 2008, the number grew to 20,176 by 2021, with a total of 85,817 electric cars in Washington State. This growth has had a substantial impact on CO2 reduction, despite other influencing factors such as population growth.

Figure 2



As shown in **Figure 3**, there was a significant decrease in CO2 emissions at a rate of -1.60% per year, dropping from 82 million metric tons in 2008 to 65 million metric tons in 2021. This decline occurred despite the increase in other factors, such as population growth, highlighting the substantial impact of electric vehicles (EVs) on CO2 reduction.

Figure 3



The analysis has proven that the increase in electric vehicle (EV) adoption has had a significant impact on the decrease in CO2 emissions over the years. As demonstrated, the rise in the number of EVs has led to a strong reduction in CO2 emissions.

What is particularly interesting is the period from 2017 to 2018, when the number of EVs increased from 8,282 to 14,209 in **Figure 2**. This notable growth had a substantial effect on CO2 emissions, as reflected in **Figure 3**, with a significant reduction in emissions observed in 2018 and 2019 with -3.83%.

CO2 Emission Reduction per EV Produced (2008-2021):

From 2008 to 2021, each electric vehicle (EV) produced in Washington State contributed to a reduction of approximately 0.02 million metric tons of CO2 emissions. This highlights the significant role of EV adoption in reducing overall carbon emissions. Although the individual reduction per vehicle may seem small, when scaled to the total number of EVs produced, this represents a meaningful contribution to mitigating climate change and improving air quality in the region.

Conclusion:

While the findings of this analysis confirm that electric vehicle (EV) adoption plays a major role in reducing CO2 emissions, it is crucial to acknowledge that this study does not account for all potential influencing factors. For example, population growth is a significant element that affects the overall level of CO2 emissions. Between 1970 and 1995, the United States saw a substantial increase in CO2 emissions, rising from 33 million metric tons to 70 million metric tons. This increase can be attributed, in part, to factors such as population growth, urbanization, and the greater demand for goods and services, all of which place additional pressure on resources and increase emissions from traditional fuel-based vehicles.

Similarly, economic conditions also play a key role in shaping emission trends. A notable example of this is the sharp decrease in CO2 emissions from 85 million metric tons in 2008 to 82 million metric tons, which can likely be attributed to the global economic crisis. The economic downturn led to a reduction in industrial activities, transportation, and overall consumption, resulting in a temporary drop in emissions. A similar pattern of emission reduction was observed in 2020, when the world faced the global COVID-19 pandemic. During the pandemic, widespread lockdowns and travel restrictions led to a sharp decline in transportation and industrial activities, contributing to a significant drop in CO2 emissions.

Despite the influence of these external factors, such as population growth, urbanization, and economic crises, **the analysis has clearly shown that the adoption of electric vehicles has been a critical strategy in reducing CO2 emissions**. While other variables undoubtedly contribute to emission trends, the data strongly suggests that the rise of electric vehicles has played a significant role in decreasing emissions, particularly as more consumers and industries make the shift away from traditional internal combustion engine vehicles. Even in the face of other global challenges, EV adoption remains a powerful tool in the ongoing effort to combat climate change and reduce the carbon footprint of transportation.