Assessing CO2 Emissions and EV Potential in the Automotive Sector

ISM6419 Data Visualization

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Project Report

Submitted By:

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Introduction:

Global warming and climate change are among the most pressing environmental challenges facing humanity today, with the primary driver being the dramatic increase in atmospheric carbon dioxide (CO2) emissions due to human activities.

Over the past century, the concentration of CO2 in the atmosphere has risen dramatically as a result of the burning of fossil fuels, deforestation, and other industrial processes. As a potent greenhouse gas, CO2 traps heat within the Earth's atmosphere, leading to a gradual rise in global temperatures. This warming effect disrupts the delicate balance of Earth's climate systems, causing widespread ecological and social consequences, such as more frequent and severe weather events, rising sea levels, and shifts in ecosystems.

Electricity generation and transportation stand out as the leading contributors to these emissions. The transportation sector, especially passenger vehicles, plays a significant role in exacerbating CO2 emissions. As the world's population grows and economies develop, the demand for personal mobility and freight transportation surges, leading to a rise in the consumption of fossil fuels and subsequent CO2 emissions.

In this report, I have provided a comprehensive analysis of the causes, impacts, and potential solutions to reduce CO2 emissions from the transportation sector, with a focus on the rise of EVs and their role in addressing this complex issue. This report will address the following research questions.

Research Questions:

1. How do greenhouse gas emissions, particularly CO2, vary across sectors and countries, and how has it impacted climate change?

2. What are the trends and major contributors to CO2 emissions within the transportation sector, considering various sub-sectors, vehicle types, and manufacturers?

3. Are electric vehicles a viable solution to reduce CO2 emissions, and what is the status of the EV charging infrastructure?

4. What is the status of net-zero carbon emissions target for various countries?

Methodology:

The methodology for this report is structured around the below process:

1. Data Collection: The analysis relied on three primary data sources to obtain relevant and comprehensive information:

    - U.S. Environmental Protection Agency (EPA) website (https://www.epa.gov/): This source provided data on CO2 emissions for the transportation sector.
    - Our World in Data website (https://ourworldindata.org/): This source offered data related to CO2 emissions across various sectors and countries.
    - International Energy Agency (IEA) website (https://www.iea.org/): This source supplied data related to electric vehicles (EVs) and their associated infrastructure.

2. Data Preparation: Tableau Prep Builder was utilized to clean, transform, and integrate the data collected from the sources. The data preparation process included the following steps:

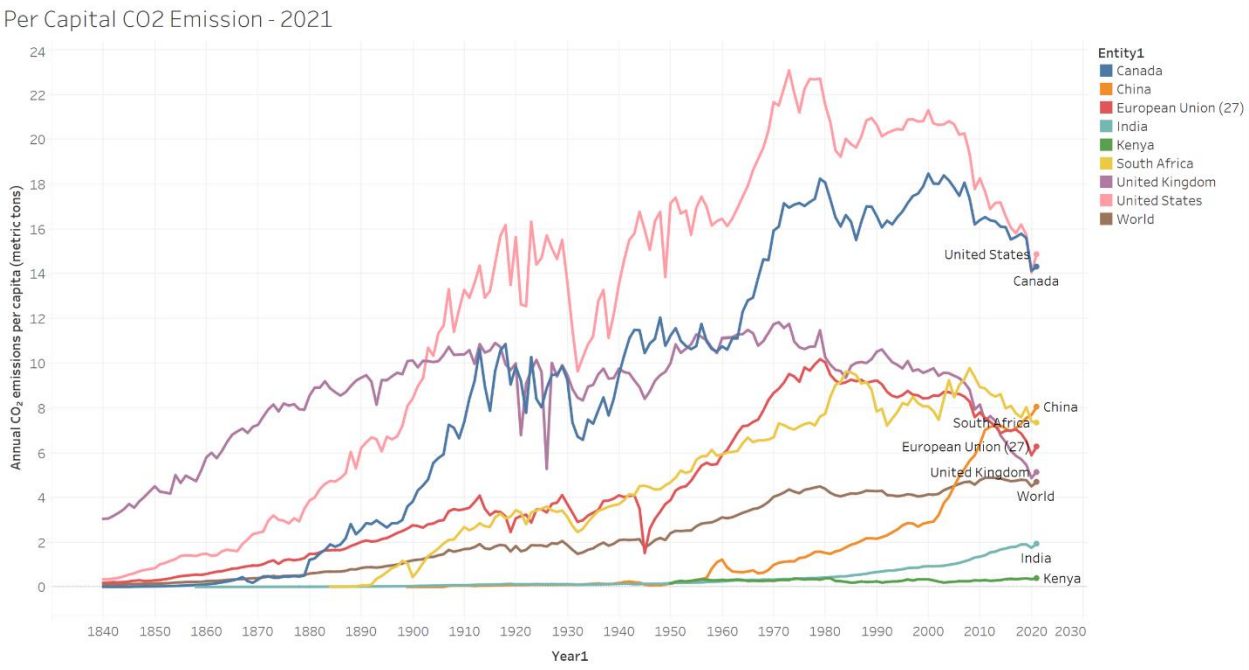
    - Connecting to each data source and importing the relevant datasets.
    - Identifying and correcting data quality issues, such as missing or inconsistent values.
    - Combining and transforming data as needed to create a unified and structured dataset for analysis.
    - Linking tables from various data sources based on the 'year' column to facilitate comparative analysis over time.

3. Data Analysis: With the cleaned and prepared dataset, the analysis was conducted in a sequential manner, starting with a broad overview, and then narrowing the focus to specific areas of interest. The steps included:

    - Analyzing CO2 emissions by sector and country to identify trends, outliers, and patterns.
    - Assessing temperature anomalies and their correlation with CO2 emissions.
    - Investigating the transportation sector, which contributes to 16.2% of emissions, and identifying the major sources of CO2 emissions within the sector.
    - Examining the growth of electric vehicles and the expansion of EV infrastructure, as well as evaluating their potential impact on CO2 emissions reduction.
    - Assessing countries' progress towards net zero carbon emissions.

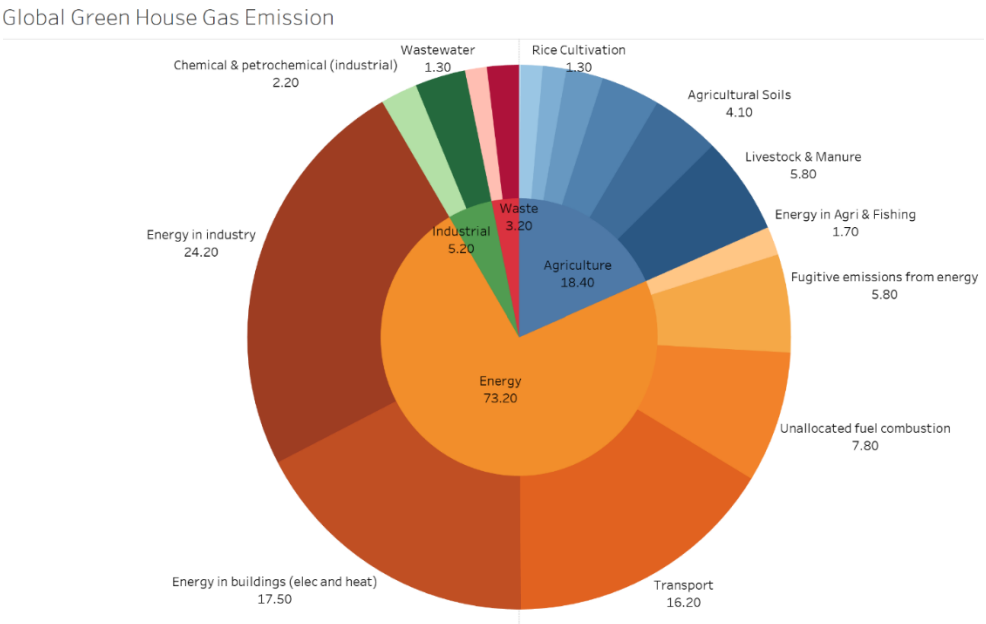
Analysis:

1. *Per Capita CO2 emissions-2021*



The graph displays CO2 emissions trends for various countries between 1840 and 2021. In 2021, the United States led with the highest CO2 emissions at 14.7 metric tons, followed by Canada with 14.3 metric tons, and China ranking third with 8.1 metric tons.

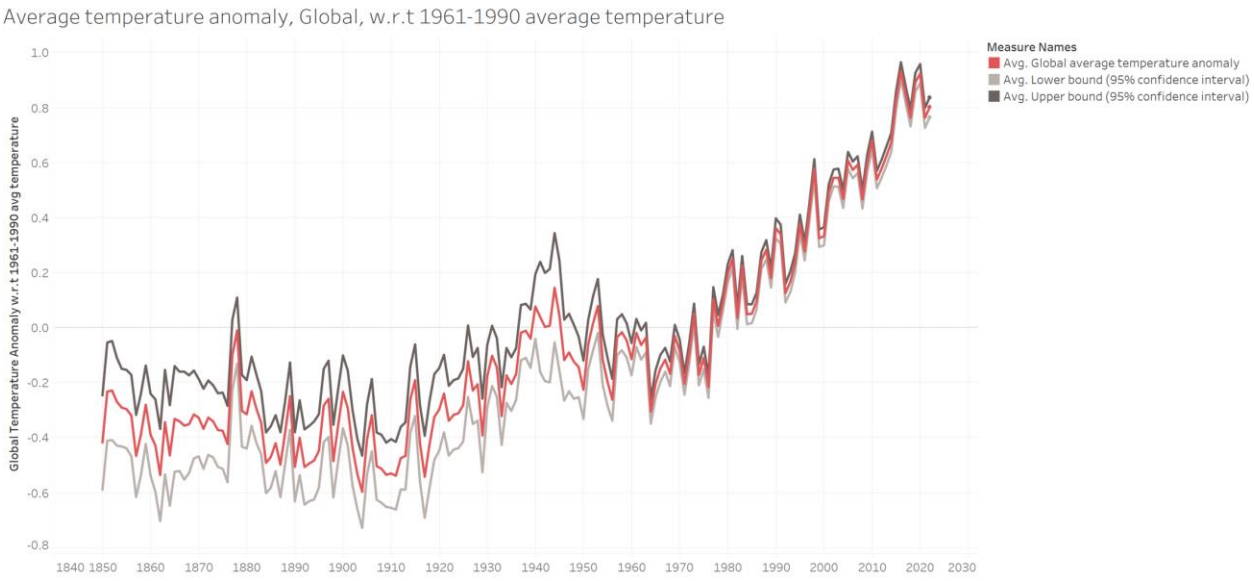
2. *Global Green House Gas Emission (By Sector and Sub-sector)*



- The visualization clearly demonstrates that the Energy Sector is the primary source of global greenhouse gas emissions, accounting for 73.2% of the total.

- Within the Energy Sector, Transportation plays a substantial role, contributing 16.2% of the sector's greenhouse gas emissions. This sub-sector is the focus of this study.

3. *<u>Average Temperature Anomaly, Global</u>*



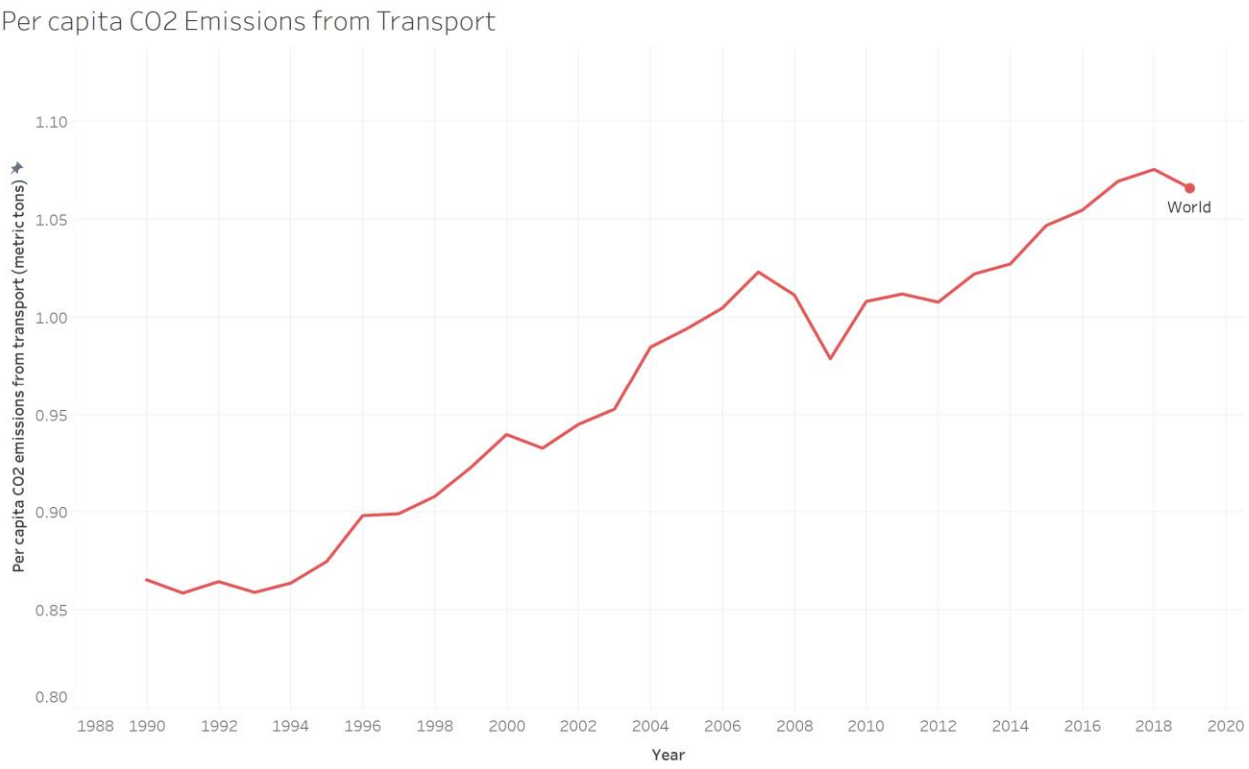
- The chart displays global average temperatures relative to the 1961-1990 baseline period.

- The red line signifies the average annual temperature trend, with light grey lines indicating upper and lower confidence intervals.

- In recent decades, global temperatures have increased by around 0.7℃ compared to the baseline, and by 1.1℃ since 1850.

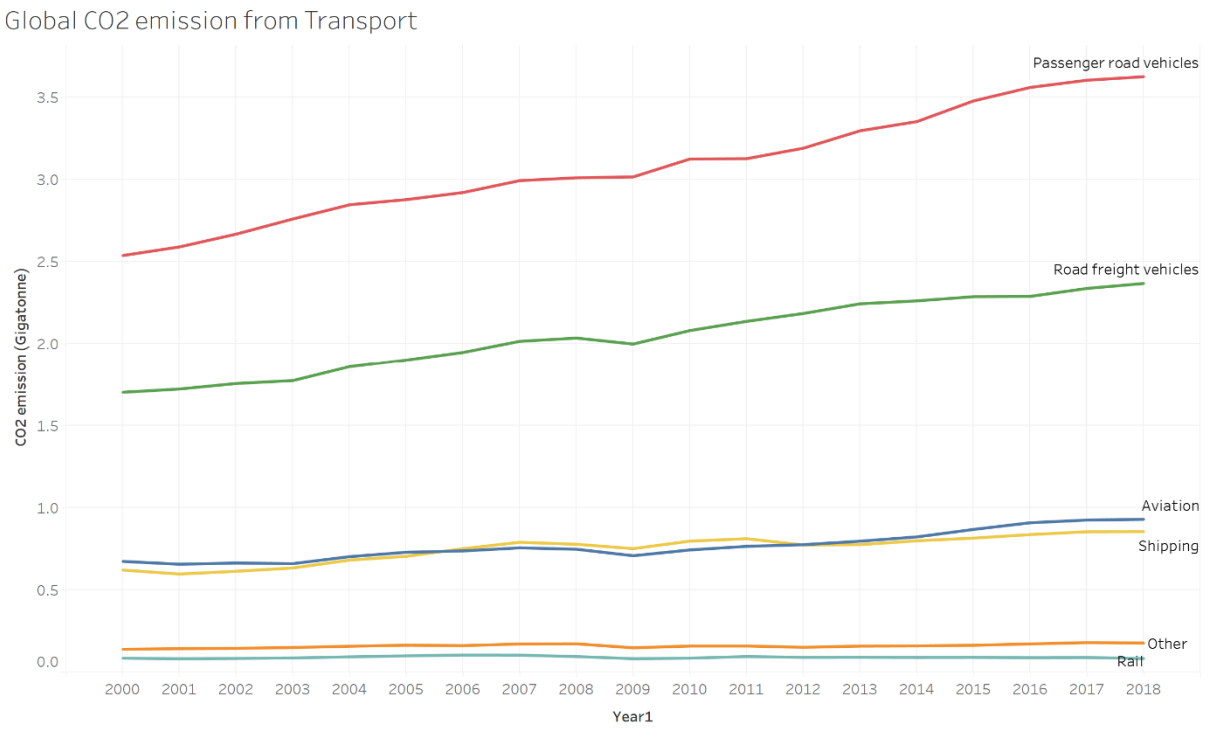
- Human-induced CO2 and greenhouse gas emissions are key contributors to climate change, representing a critical global challenge.

4. *<u>Per Capita CO2 Emission from Transport</u>*



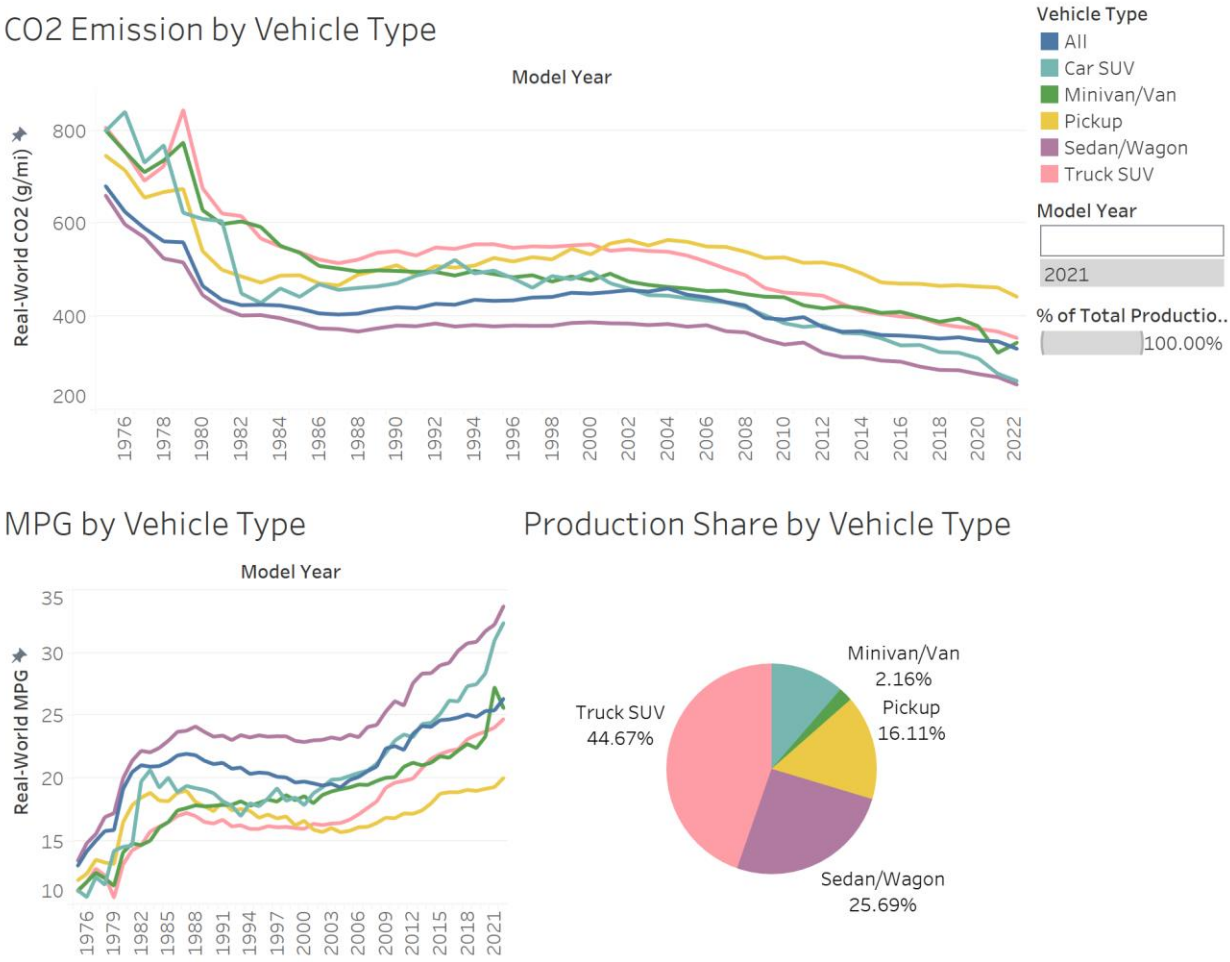
The chart illustrates the increasing trend in per capita CO2 emissions from transport between 1990 and 2019, with the latest data showing 1.1 metric tons in 2019.

5. *<u>CO2 emissions from various Transportation Sub-Sectors</u>*



- The figure presents 2019 CO2 emissions data for various transportation sub-sectors.
- Passenger road vehicles have the highest emissions at 3.6 gigatons, followed by road freight vehicles with 2.4 gigatons.

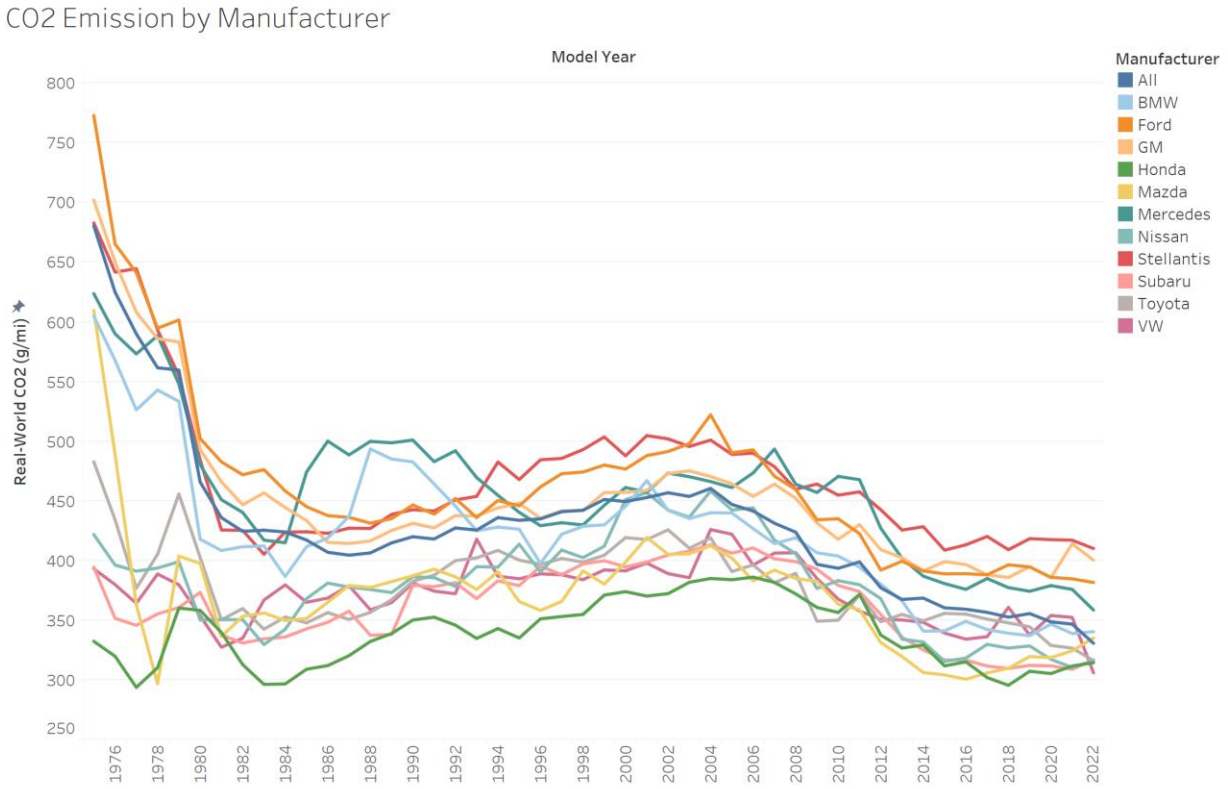
6. *Dashboard for Vehicle Type*

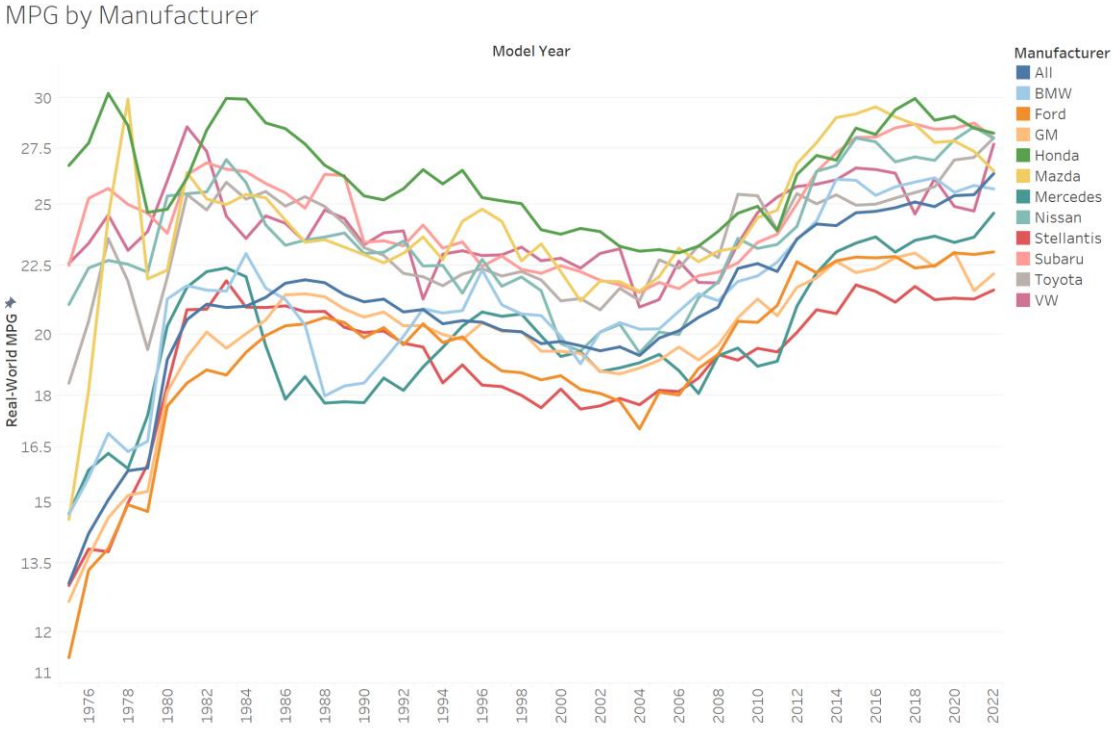


The above Dashboard reflects the below points:

- The decline in CO2 emissions can be attributed to the increase in MPG (miles per gallon) across vehicle types.
- The improvement in MPG is particularly impactful given the production share distribution, with Truck SUVs representing the largest share at 44.7%, followed by Sedans at 25.7%, and Pickups at 16.1%.

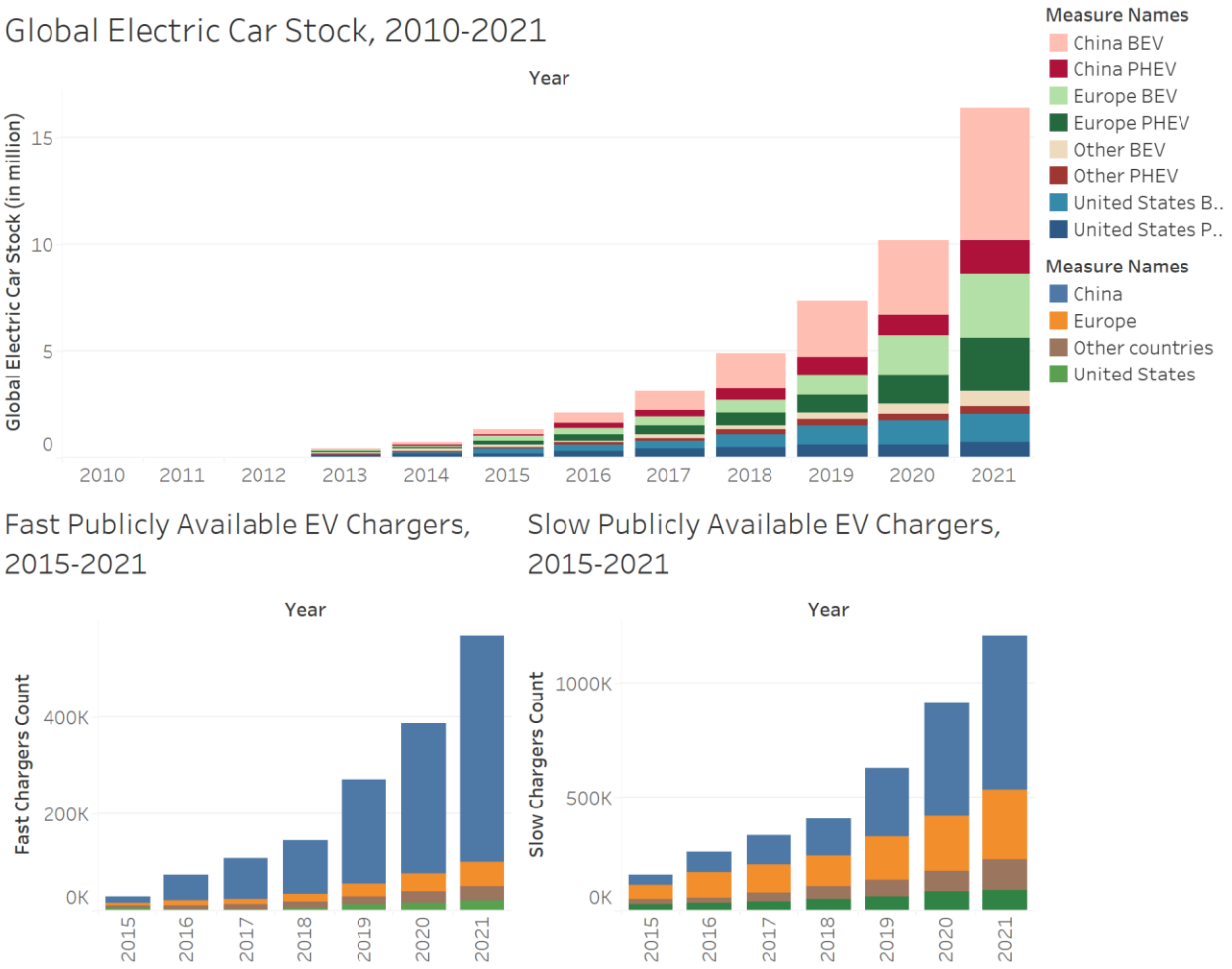
7. *CO2 and MPG Trend by Manufacturer*





- The charts illustrate a consistent decrease in CO2 emissions across all manufacturers, which corresponds with an increase in MPG for each manufacturer. This demonstrates that improved fuel efficiency is a key factor in reducing CO2 emissions within the automotive industry.

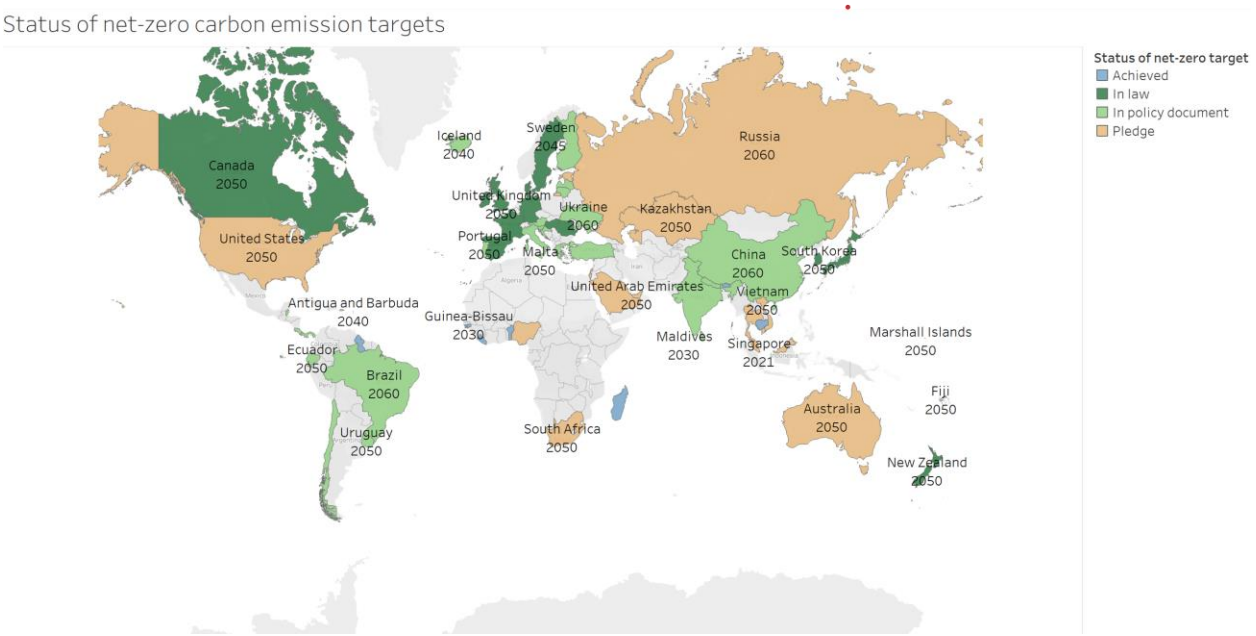
8. *EV Stock and Chargers Dashboard*



- The chart highlights the growth in global electric car stock from 2010 to 2021, with China having the largest share at 7.8 million vehicles, followed by Europe at 5.5 million, showcasing the rising popularity of electric vehicles worldwide.

- The dashboard also reveals an increase in the number of publicly available EV chargers, both fast and slow chargers, with China leading the way (fast: 470,000; slow: 677,000) and Europe following (fast: 49,000; slow: 307,000), indicating a growing EV infrastructure to support the transition to electric mobility.

9. *<u>Status of Net-Zero Carbon Emission Targets</u>*



- The map showcases the status of countries' progress towards net-zero carbon emissions targets, with Guyana, Guinea-Bissau, Madagascar, and Vietnam having already achieved their goals.

- Notable countries, including Canada, France, the UK, Sweden, and New Zealand, have incorporated net-zero commitments into their laws, while others like China, India, Ukraine, Turkey, Latvia, and Estonia have documented their ambitions in policy documents.

- The majority of remaining countries have pledged to pursue net-zero carbon emissions, reflecting a global recognition of the need to combat climate change and transition to a sustainable future.

Conclusion:

The following conclusion can be drawn from the above analysis:

- Greenhouse gas emissions have significantly impacted climate change in recent decades, with the transportation sub-sector contributing 16.2% of CO2 emissions within the energy sector.
- CO2 emissions from various manufacturers and vehicle types have been declining due to improvements in fuel efficiency, as higher MPG values lead to lower emissions per mile driven.
- The expanding global EV stock and infrastructure indicate growing support for the transition to electric mobility.
- A majority of countries have achieved, enshrined in laws, or pledged to pursue net-zero carbon emissions, emphasizing a global commitment to combating climate change and promoting a sustainable future.

The following research questions present potential avenues for deepening our understanding of this complex issue. While they are not covered in the current study, they may be more appropriately addressed in future work:

- What role do alternative fuels, such as biofuels and hydrogen, play in reducing CO2 emissions from the transportation sector, and what are the challenges and opportunities for their large-scale deployment?
- How can public transportation systems and urban planning strategies contribute to reducing CO2 emissions in major cities around the world?
- How does the availability and accessibility of charging infrastructure influence the adoption of electric vehicles in different regions?
- How do government policies, incentives, and regulations impact the pace of CO2 emissions reduction in the transportation sector, particularly for electric vehicles?
- How do consumer behavior and preferences influence CO2 emissions from the transportation sector, and what strategies can be employed to promote more sustainable choices?