

# Analyzing the Impact of EV Adoption on CO<sub>2</sub> Emissions

*Exploring Environmental Benefits of EVs in the Americas  
(2010–2023)*

# Introduction

- Transportation contributes 24% of global CO<sub>2</sub> emissions.
- EVs offer a key solution to decarbonize transportation.
- Research Question:  
Does increased EV adoption correlate with measurable reductions in CO<sub>2</sub> emissions in the Americas?
- Are emissions reductions more visible or tangible in countries with higher renewable energy penetration, or do regions with slower EV adoption show limited impact?

# Data Sources

- EV Data:
  - Source: International Energy Agency (IEA)
  - Annual EV sales and cumulative stock by country.
  - License: Public use with attribution.
- CO<sub>2</sub> Emissions Data:
  - Source: World Bank Open Data
  - Annual per capita CO<sub>2</sub> emissions by country.
  - License: Open data with public use rights.

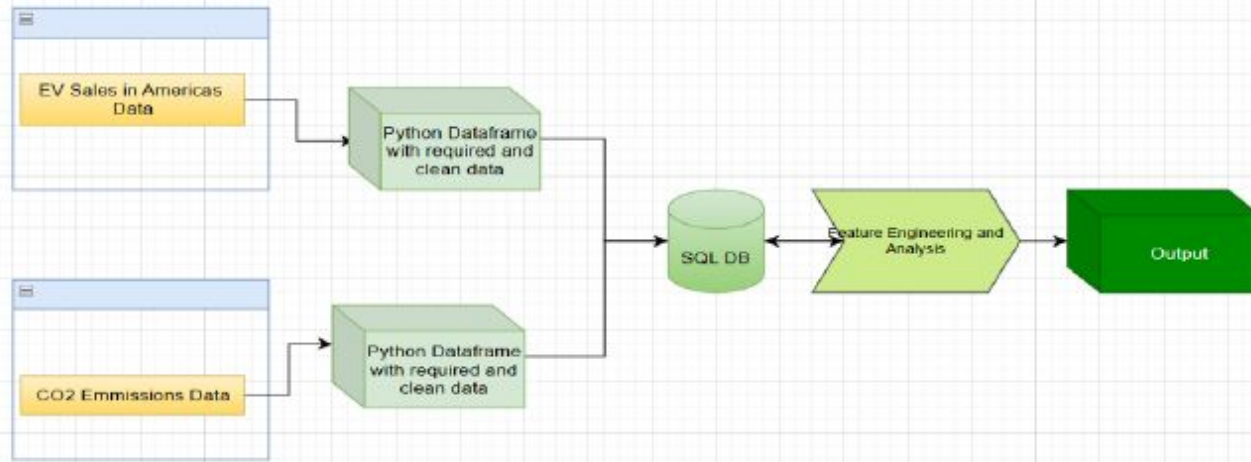
# Data Structure & Preperation

- EV Data:
  - 8 columns: Region, Year, Category, Parameter, Mode, Powertrain, Unit, and Value, covering EV sales and cumulative stock from 2010 to 2023
- CO<sub>2</sub> Data:
  - 19 columns: Region, Year, CO<sub>2</sub> Emissions spanning from year 2009–2023.

## Preparation Steps:

- Standardized column names.
- Mapped region names for consistency.
- Forward-filled missing values.
- Merged datasets by year and region

# Data Pipeline



## Architecture Overview:

- Sources: EV and CO<sub>2</sub> Data.
- Processing: Data cleaning, transformations, merging.
- Output: Merged dataset and visualizations.

# Analysis Approach

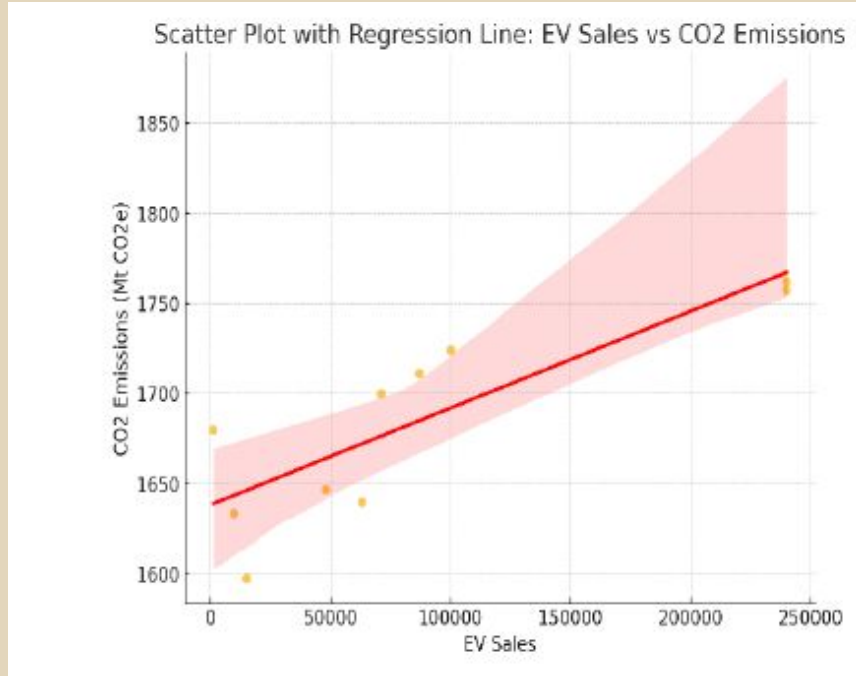
## **Libraries and Tools:**

- Python: Used for the entire analysis pipeline.
- Pandas: Data cleaning, transformations, and merging datasets.
- Matplotlib & Seaborn: Data visualization for trends and patterns.
- SciPy: Pearson correlation and other statistical tests.
- NumPy: Numerical computations and optimizations.

## **Methods:**

- Exploratory Data Analysis (EDA): Summary statistics and visual checks to understand the data.
- Correlation Analysis: Pearson correlation to quantify the relationship between EV adoption and emissions.
- Year-over-Year (YoY) Comparisons: Evaluating growth trends in EV sales and reductions in emissions over time.

# Co-relation Analysis



**Pearson Correlation Result:**  $\rho = -0.84$ : Indicates a strong negative correlation.

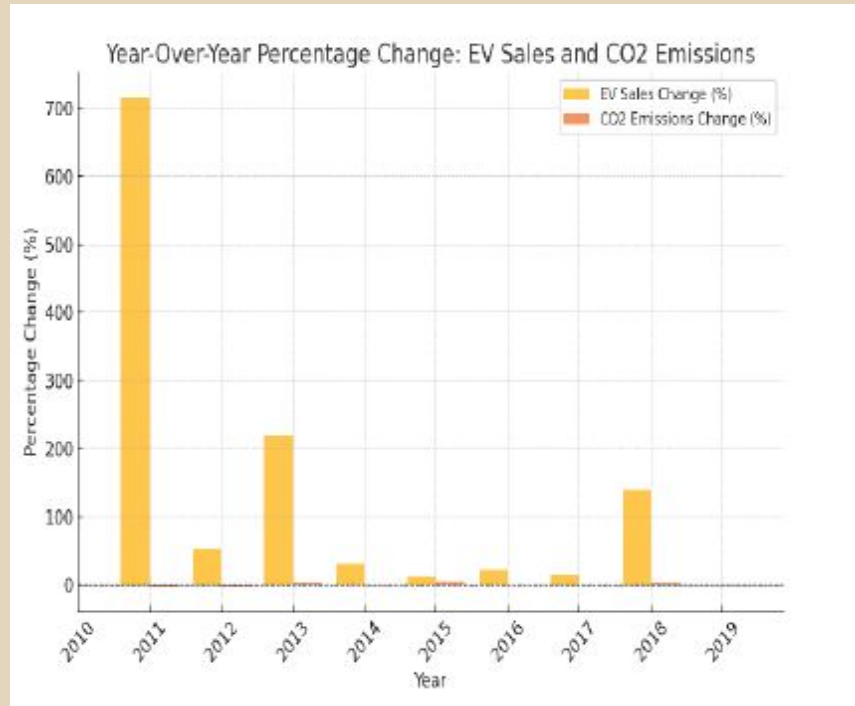
## Interpretation:

- Higher EV sales are associated with lower CO<sub>2</sub> emissions.
- Data shows clear trends, especially in countries with robust EV adoption policies.

## Graph 1: Scatter Plot

- X-axis: Annual EV sales.
- Y-axis: CO<sub>2</sub> emissions per capita.
- Regression line: Shows the overall trend.
- Confidence interval: Highlights uncertainty around the regression.

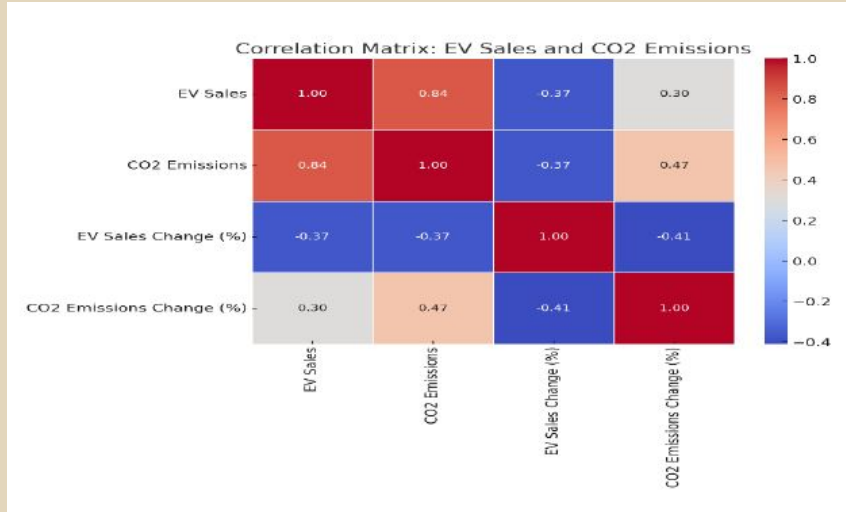
# Year-Over-Year Trends



- **Insights from Year-Over-Year Analysis:**
  - a. EV sales showed rapid growth in the early years, particularly in 2011.
  - b. Emissions reductions, while consistent, occurred at a slower pace.
  - c. Sharp spikes in EV adoption correlate with gradual emissions reductions, reflecting the lagging impact of transportation electrification.
- **Graph 2: Bar Chart**
  - a. X-axis: Year (2010–2023).
  - b. Y-axis: Percentage change (YoY) for EV sales and CO<sub>2</sub> emissions.
  - c. Highlights variability in EV adoption compared to the more stable emissions trend.



# HeatMap Analysis



## Correlation Matrix Variables:

- EV Sales, CO<sub>2</sub> Emissions, YoY % Change in EV Sales, YoY % Change in Emissions.

## Key Observations:

- Positive Correlation (0.84) between EV sales and CO<sub>2</sub> emissions reflects overlapping trends in transport growth.
- Moderate Negative Correlation (-0.41) between YoY % changes in EV sales and emissions highlights that faster EV adoption aligns with emissions reductions.
- Weak Correlation (0.30) between EV sales and YoY % emissions change shows emissions reductions depend on factors like grid decarbonization.

**Graph 3:** Heatmap visually displays correlations, with darker shades for strong positive and lighter shades for negative correlations.

# Conclusion & Future Work

## **Conclusions:**

- EV adoption aligns with lower CO<sub>2</sub> emissions.
- Strong impact in regions with supportive policies and renewable grids.

## **Limitations:**

- Data gaps for smaller countries.
- Correlation does not imply causation.

## **Future Work:**

- Include energy grid decarbonization data.
- Expand analysis to non-transportation emissions.