State-by-State Carbon Emission Trends: A Decade of Insights Among U.S. States

Naga Deepak Pagadala, Neeraj Kondaveeti

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Abstract

This project investigates greenhouse gas (GHG) emissions trends across U.S. states from 2010 to 2022. Using data from the EPA's Greenhouse Gas Reporting Program (GHGRP), we developed interactive visualizations to explore emissions across states and sectors, highlight top emitters, and assess the impact of key environmental policies like the Clean Power Plan and the Paris Agreement. The findings emphasize the limitations of current policies and underscore the need for stronger climate action.

1 Introduction

1.1 Background

Greenhouse gases are key drivers of climate change, with U.S. states contributing differently based on population, industries, and energy sources. The EPA's GHGRP provides facility-level emissions data but lacks aggregated state-level insights. This project addresses these gaps by analyzing emissions trends over a decade, focusing on spatial, temporal, and sectoral dimensions to uncover actionable insights.

1.2 Motivation and Objectives

Despite policies like the Clean Power Plan and the Paris Agreement, their tangible impacts on emissions reduction remain unclear. This project aims to:

- Investigate emissions trends over time.
- Evaluate sector-wise contributions to emissions.
- Assess policy effectiveness.
- Create an interactive tool for stakeholders.

2 Process

2.1 Data Collection and Cleaning

- **Sources:** EPA's GHGRP (2010-2022).

- **Cleaning:** Imputation and exclusion of missing values; aggregation at state and sector levels.

2.2 Visualization Development

- **Tools:** Python libraries (pandas, Plotly, Matplotlib).
- **Dashboard:** Built using Dash for interactive filtering and analysis.

2.3 Challenges and Solutions

- **Data Inconsistencies:** Addressed with automated cleaning scripts.
- **Large Datasets:** Optimized workflows for efficiency.
- **Policy Context:** Annotated timelines on visualizations.

3 Results and Insights

3.1 Key Visualizations

- **State-by-State Bar Chart:** Total emissions comparison.
- **Sector-Wise Pie Chart:** Distribution of emissions.
- **Temporal Line Charts:** Trends with policy annotations.
- **Choropleth Maps:** Geographic emissions intensity.
- **Interactive Dashboard:** Dynamic filtering by state and sector.

3.2 Key Insights

- Limited immediate impact from policies like the Clean Power Plan and Paris Agreement.
- High emissions states (e.g., Texas, Louisiana) require targeted interventions.
- Energy and industrial sectors dominate emissions, demanding aggressive measures.

4 Discussion, Conclusion, and Future Work

4.1 Discussion

Policy impacts are subtle and often influenced by external factors, highlighting the need for stronger enforcement and complementary measures.

4.2 Conclusion

The project delivers an interactive dashboard and visualizations, providing actionable tools for researchers and policymakers.

4.3 Future Work

- Incorporate real-time emissions data.
- Expand analysis to other greenhouse gases.
- Apply predictive analytics for forecasting trends.
- Enhance dashboards with "what-if" scenarios.

5 References

- U.S. Environmental Protection Agency. *GHGRP emissions by location.*
- International Energy Agency (IEA). (2023). *Global CO2 emissions report.*