Impact of Renewable Energy Consumption on CO_2 Emissions Across U.S.

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Advanced Methods of Data Engineering
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Contents

Introduction

This project investigates the relationship between renewable energy adoption across different sectors and states in the U.S. and its impact on carbon dioxide (CO_2) emissions. The goal is to analyze trends, uncover correlations, and provide actionable insights to support sustainable development strategies.

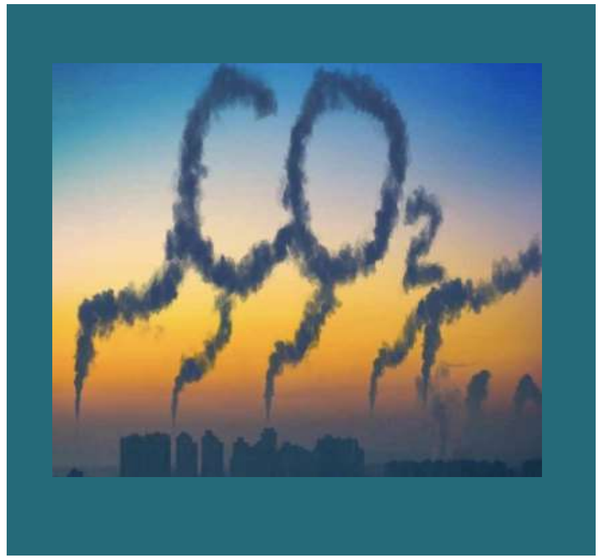
Project Goals

Within the project scope, I'm curious about the following questions :

- How does renewable energy consumption influence CO_2 emissions across U.S. sectors?

- Provide actionable insights for sustainable policy formulation.

Datasets



$CO_2 Emission$

- **Metadata URL:**

  https://www.kaggle.com/datasets/abdelrahman16/co2-emissions-usaData

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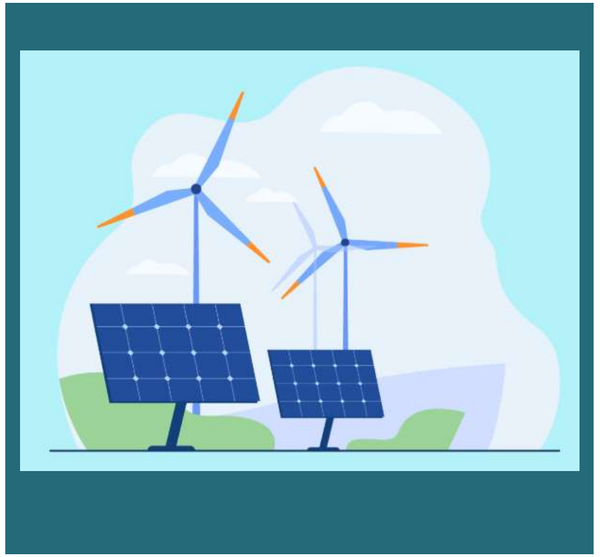
  https://www.kaggle.com/datasets/abdelrahman16/co2-emissions-usa

- **Data Type: CSV**



$Renewable\ Energy$

- **Metadata URL:**

  https://www.kaggle.com/datasets/alistairking/renewable-energy-consumption-in-the-u-s)

- **Data URL:**

  hhttps://www.kaggle.com/datasets/alistairking/renewable-energy-consumption-in-the-u-s?resource=download

- **Data Type: CSV**

Methodology

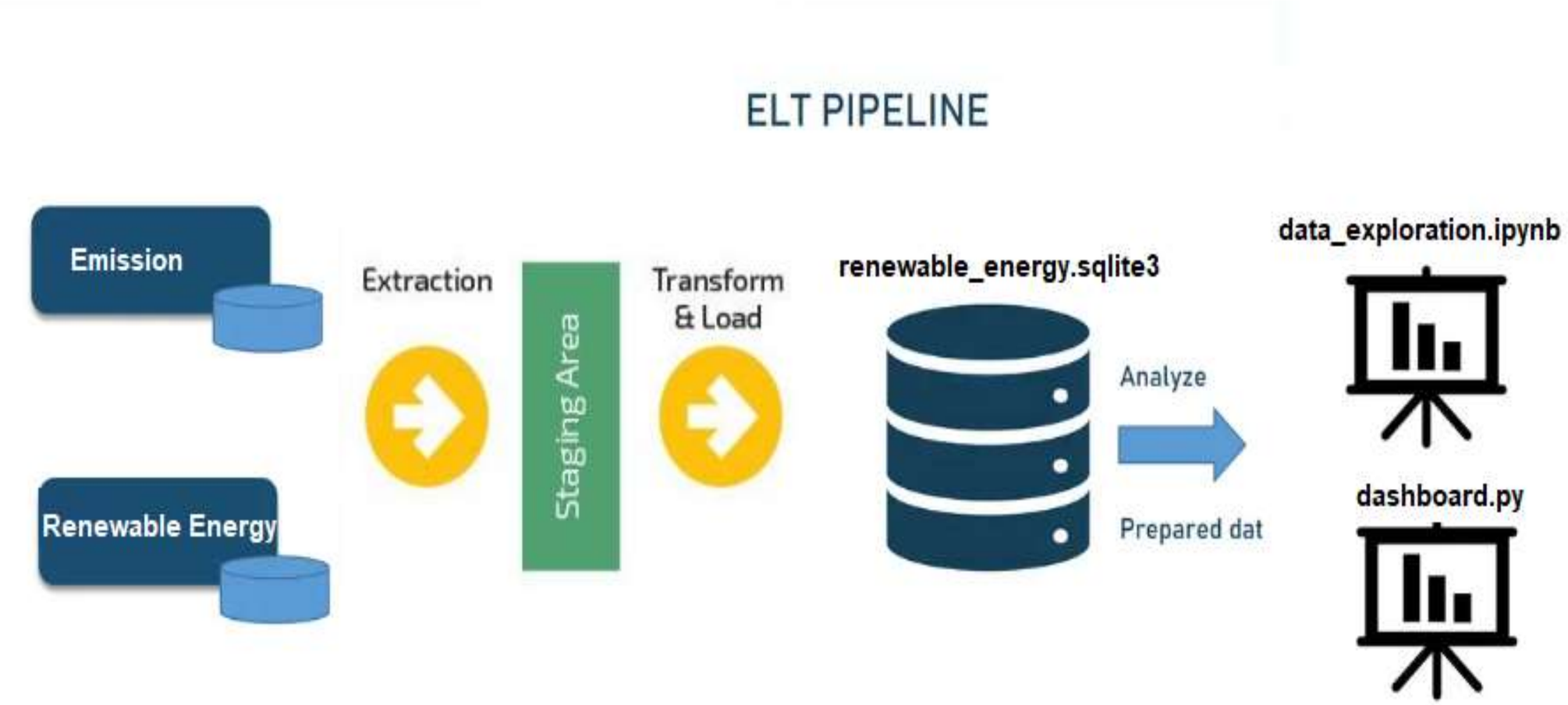
Data Pipeline:

- Download and preprocess data.
- Merge datasets and filter by year.
- Store in SQLite database.

Key Steps:

1. Handle column inconsistencies.
2. Data validation and cleaning.
3. Trend analysis and insights extraction.

ETL-Pipeline



Data stored in data base

Data from SQLite:

	year	state-name	sector-name	fuel-name	value
0	1973	Alabama	Industrial carbon dioxide emissions	Coal	23.552431
1	1973	Alabama	Industrial carbon dioxide emissions	Petroleum	5.541595
2	1973	Alabama	Industrial carbon dioxide emissions	Natural Gas	8.300523
3	1973	Alabama	Industrial carbon dioxide emissions	All Fuels	37.394549
4	1973	Alabama	Total carbon dioxide emissions from all sectors	All Fuels	109.563135

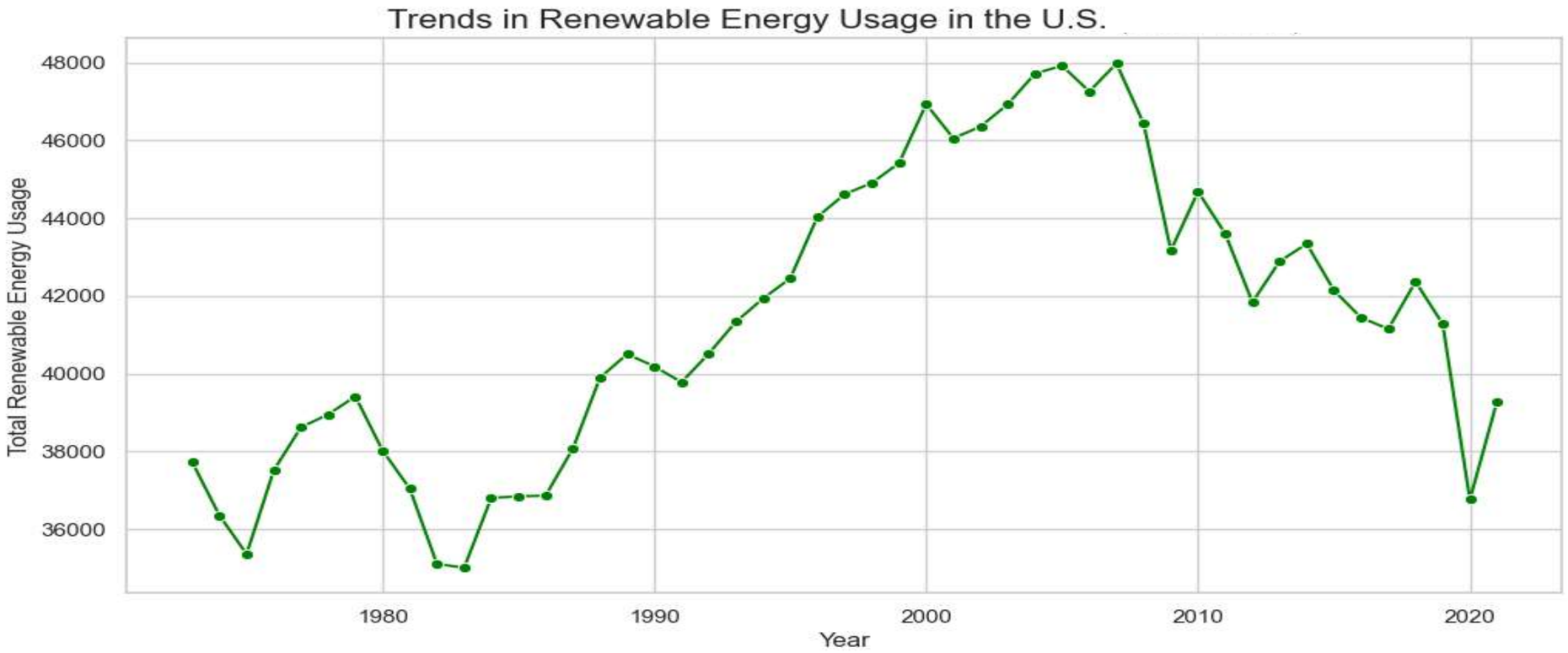
Results

Trend 1: Increased Renewable Energy Usage
- Growth accelerated post-1985 and then declined after 2008

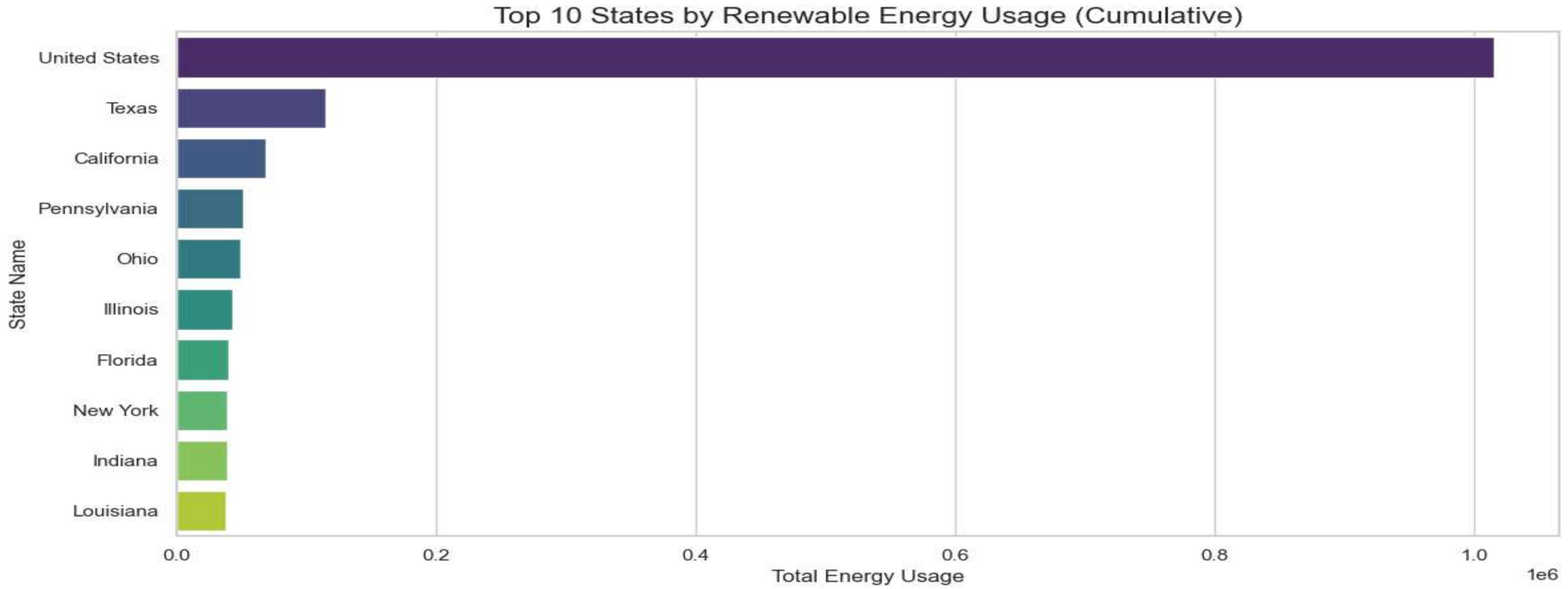
Trend 2: Leading States
- California, Texas, and New York lead renewable adoption.

Trend 3: Sector Contributions
- Dominated by electricity generation.

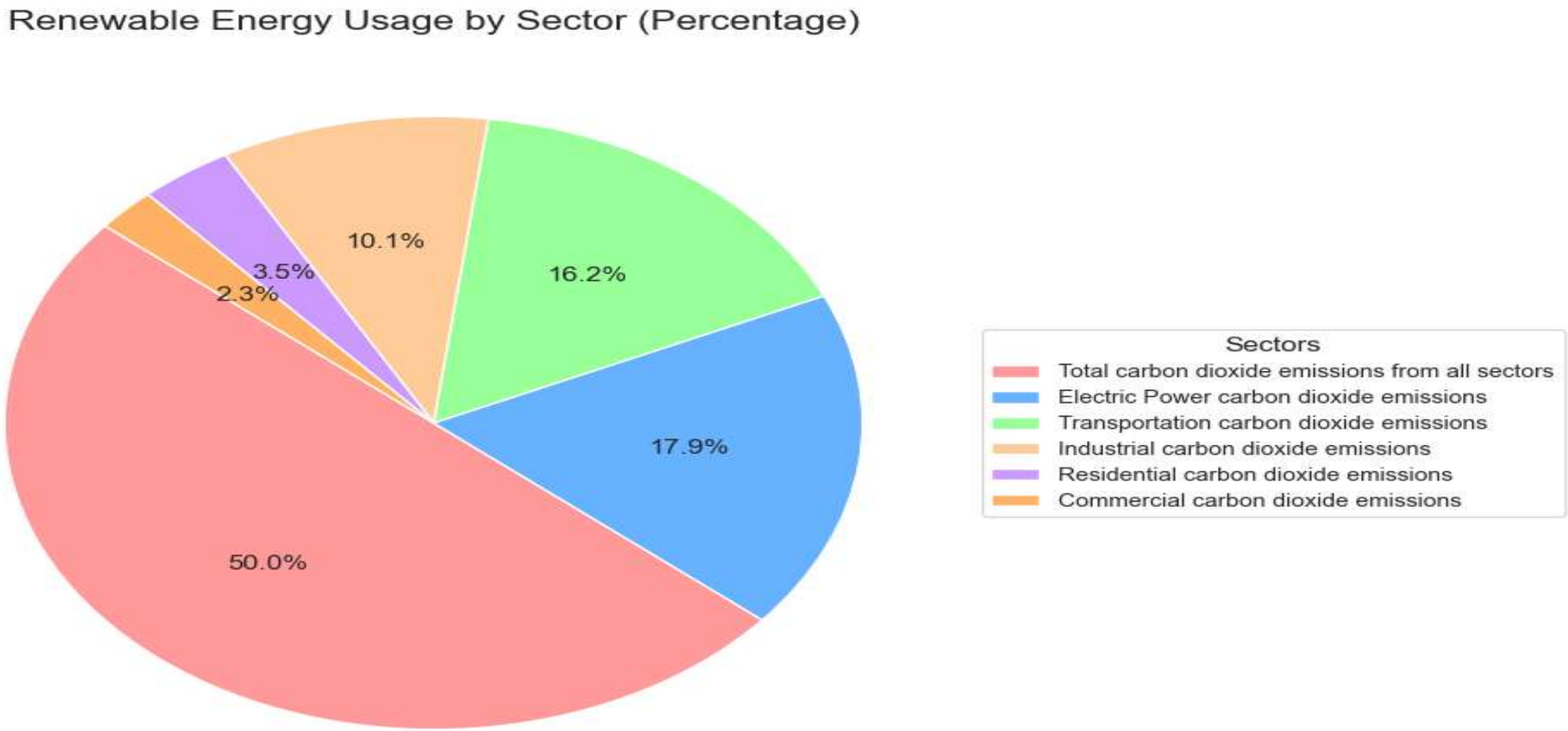
Increased Renewable Energy Usage

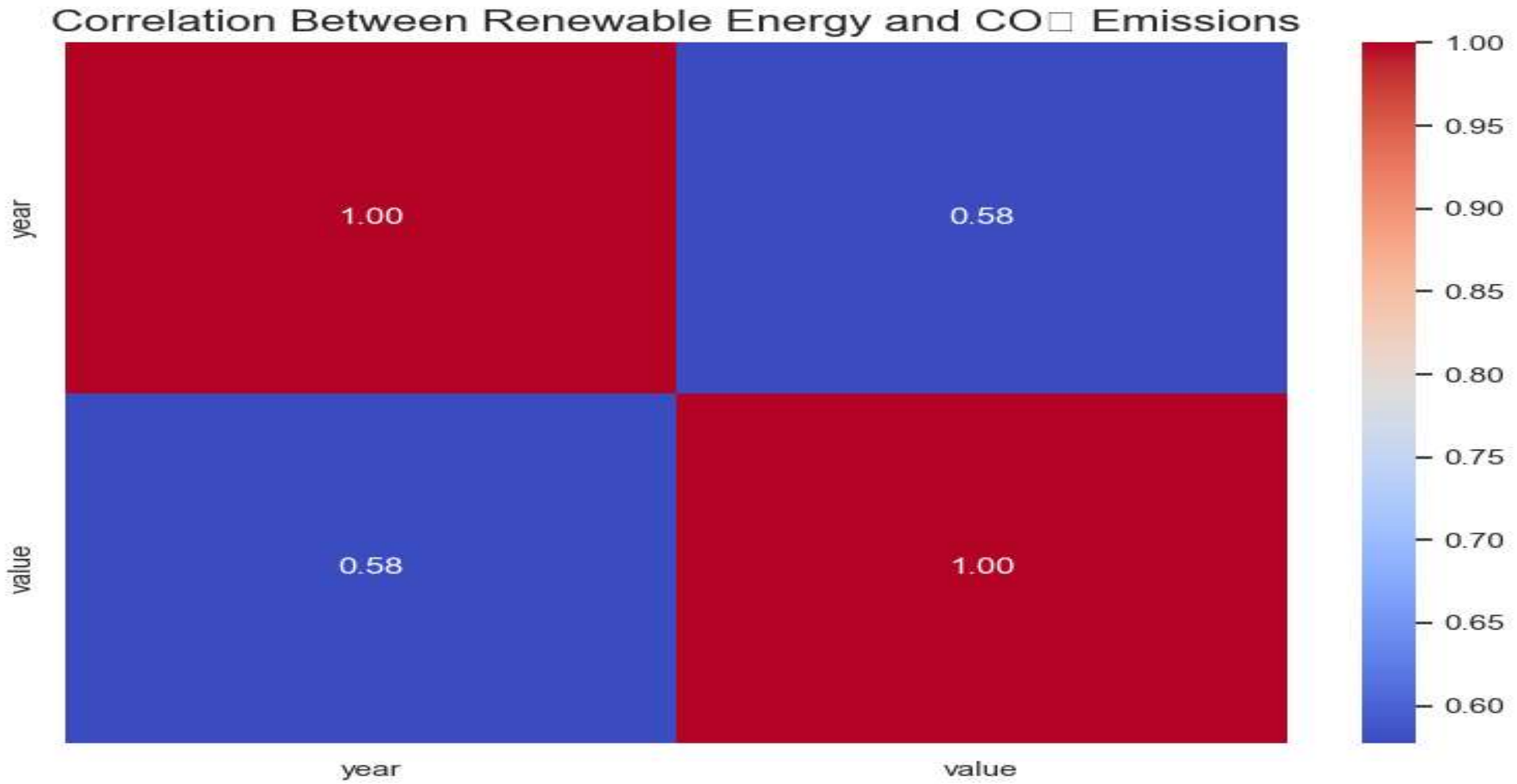


Leading States in Renewable energy usage

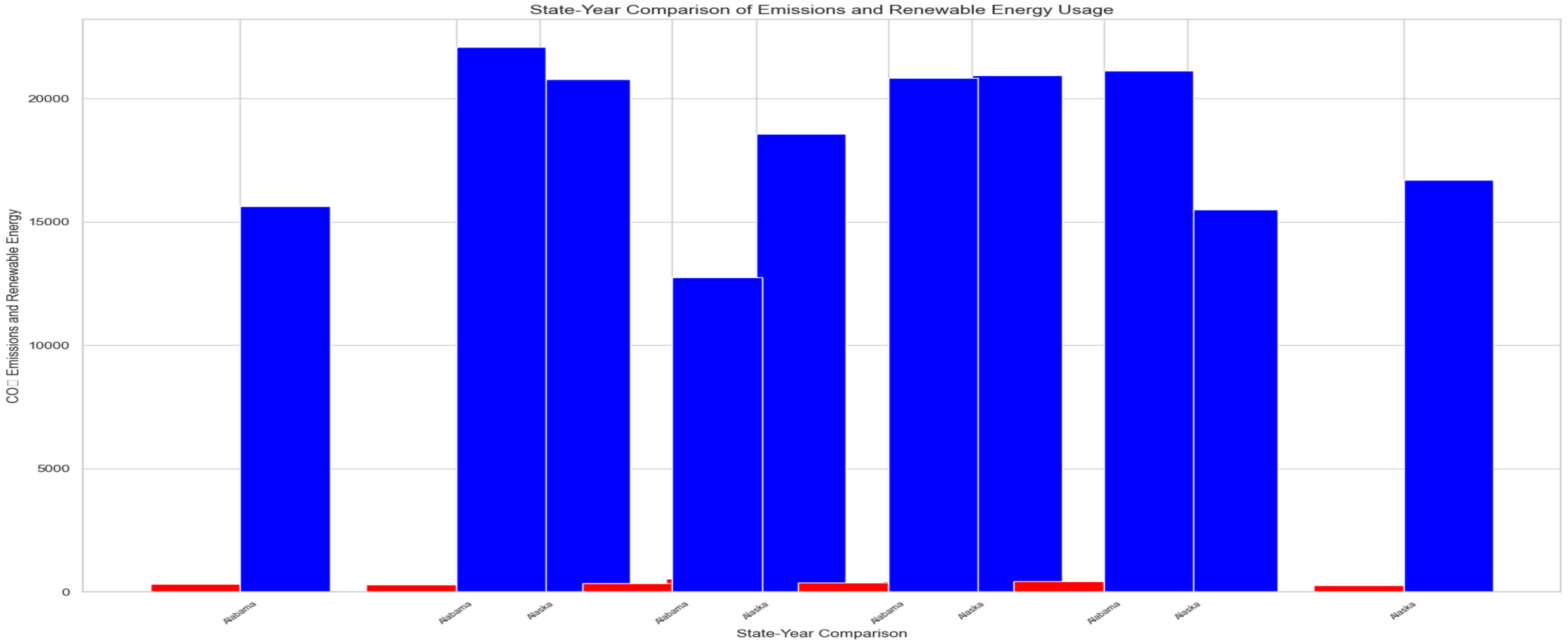


Renewable Energy Sector Contributions




Correlation Between Renewable Energy and CO□ Emissions
year
value
1.00
0.58
0.58
1.00
year
value
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60

State&year vs co_2Emission&Renewable Energy



Conclusion

The analysis demonstrates a strong link between renewable energy adoption and reduced CO_2 emissions in the U.S. Renewable energy's rising adoption, particularly in leading states and critical sectors, has driven emission reductions, offering valuable lessons for policymakers. However, expanding renewable adoption to underperforming sectors like transportation and addressing regional disparities will be essential to meeting broader sustainability goals. Future work should incorporate real-time and geospatial analytics to enhance insights and guide actionable policies.

Challenges and Limitations

- **Data Gaps:** Historical data contains minor gaps, which may marginally impact trend accuracy.
- **Scalability:** As data grows, computational performance may require optimization.
- **Regional Specificity:** Analysis focuses on aggregate U.S. trends; regional or sector-specific variations may need deeper exploration.

Thank you!