VISUALIZING CLIMATE ACTION : MONITORING PROGRESS TOWARDS SDG 13

Tableau project

CHRIST (Deemed to be University) Central Campus, Bangalore

MDS411- Data driven modeling and Visualization

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Introduction

As the world continues to advance and modernize, the environmental consequences of industrialization and economic growth have become increasingly apparent. Among the most pressing concerns is the rise in CO2 emissions, which contribute significantly to global climate change. To better understand the factors driving these emissions, a comprehensive dataset has been compiled using data from the US Energy Administration. This dataset provides a detailed examination of the energy production and consumption patterns of various countries, alongside critical economic indicators such as GDP and population. By analyzing data from the 1980s through 2020, this dataset offers valuable insights into the relationships between energy use, economic development, and environmental impact on a global scale.

Dataset

This dataset, compiled from the US Energy Administration, brings together key factors that contribute to CO2 emissions. It includes data on the production and consumption of major energy sources for each country, along with their pollution ratings over the years. Additionally, the dataset provides insights into each country's GDP, population, energy intensity per capita, and energy intensity per GDP. The data spans from the 1980s to 2020, offering a comprehensive view of global energy use and its environmental impact.

Feature Descriptions:

- **Country**: The country in question.
- **Energy_type**: The type of energy source.
- **Year**: The year the data was recorded.
- **Energy_consumption**: The amount of energy consumption for the specific energy source, measured in quad Btu.
- **Energy_production**: The amount of energy production for the specific energy source, measured in quad Btu.
- **GDP**: The country's GDP at purchasing power parities, measured in billion 2015$ PPP.

- **Population**: The population of the specific country, measured in millions of people (Mperson).
- **Energy_intensity_per_capita**: A measure of the energy inefficiency of an economy, calculated as units of energy per unit of capita, measured in MMBtu/person.
- **Energy_intensity_by_GDP**: A measure of the energy inefficiency of an economy, calculated as units of energy per unit of GDP, measured in 1000 Btu/2015$ GDP PPP.
- **CO2_emission**: The amount of CO2 emitted, measured in million tonnes of CO2 (MMtonnes CO2).

The Global Energy Consumption Landscape

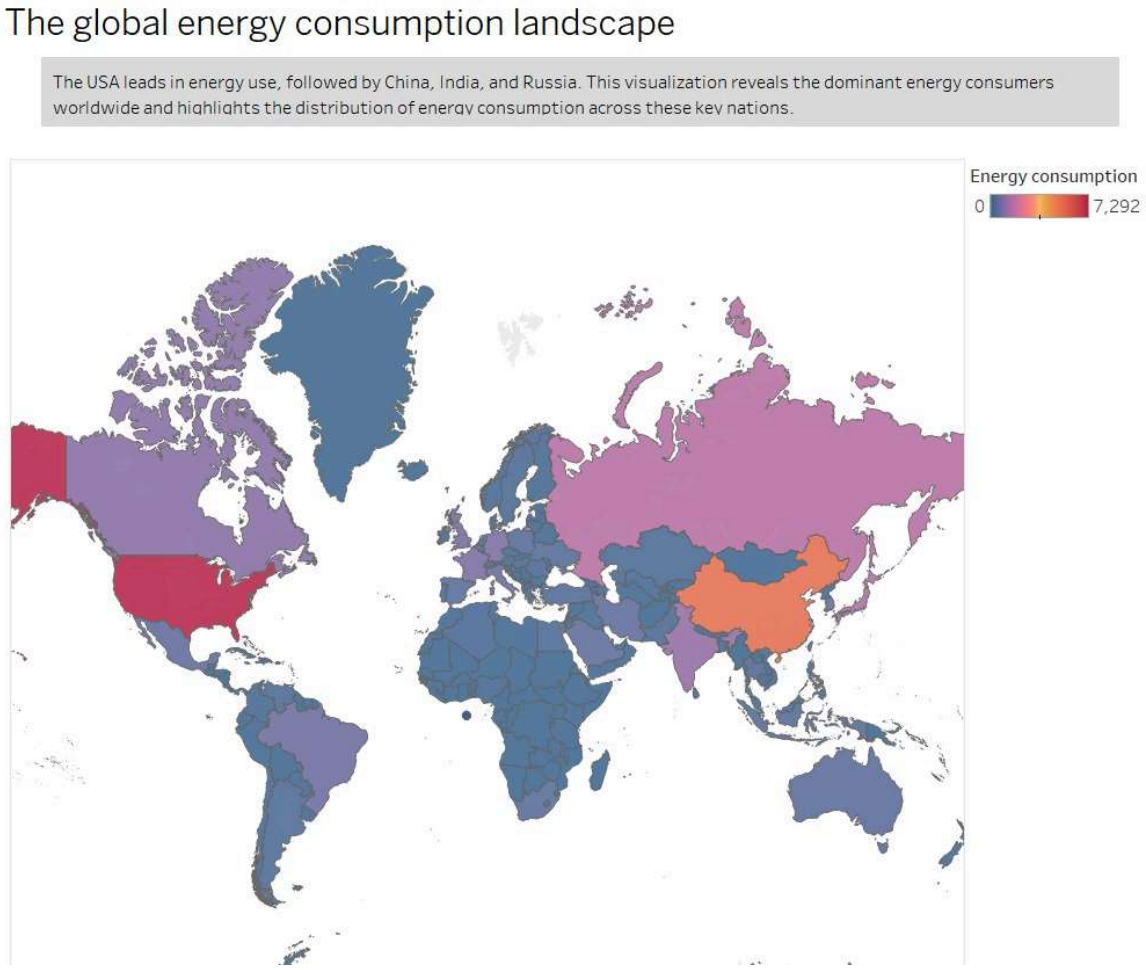

Fig 1 : The global energy consumption landscape

The global energy consumption landscape reveals significant disparities, with the United States, China, and Russia leading as the top energy consumers, driven by their large industrial bases, economic growth, and reliance on energy-intensive technologies. China and India's rapid industrialization and urbanization have propelled them to the forefront of global energy demand, while Western Europe maintains moderate consumption levels due to investments in energy efficiency and renewables. In contrast, developing regions like Africa and South America exhibit lower energy use but are expected to see rising demand as they industrialize. This growing global energy consumption is closely linked to environmental challenges, particularly increasing CO2 emissions, underscoring the need for strategies that balance energy demand with sustainability.

Global Energy Source Popularity and Consumption Trends

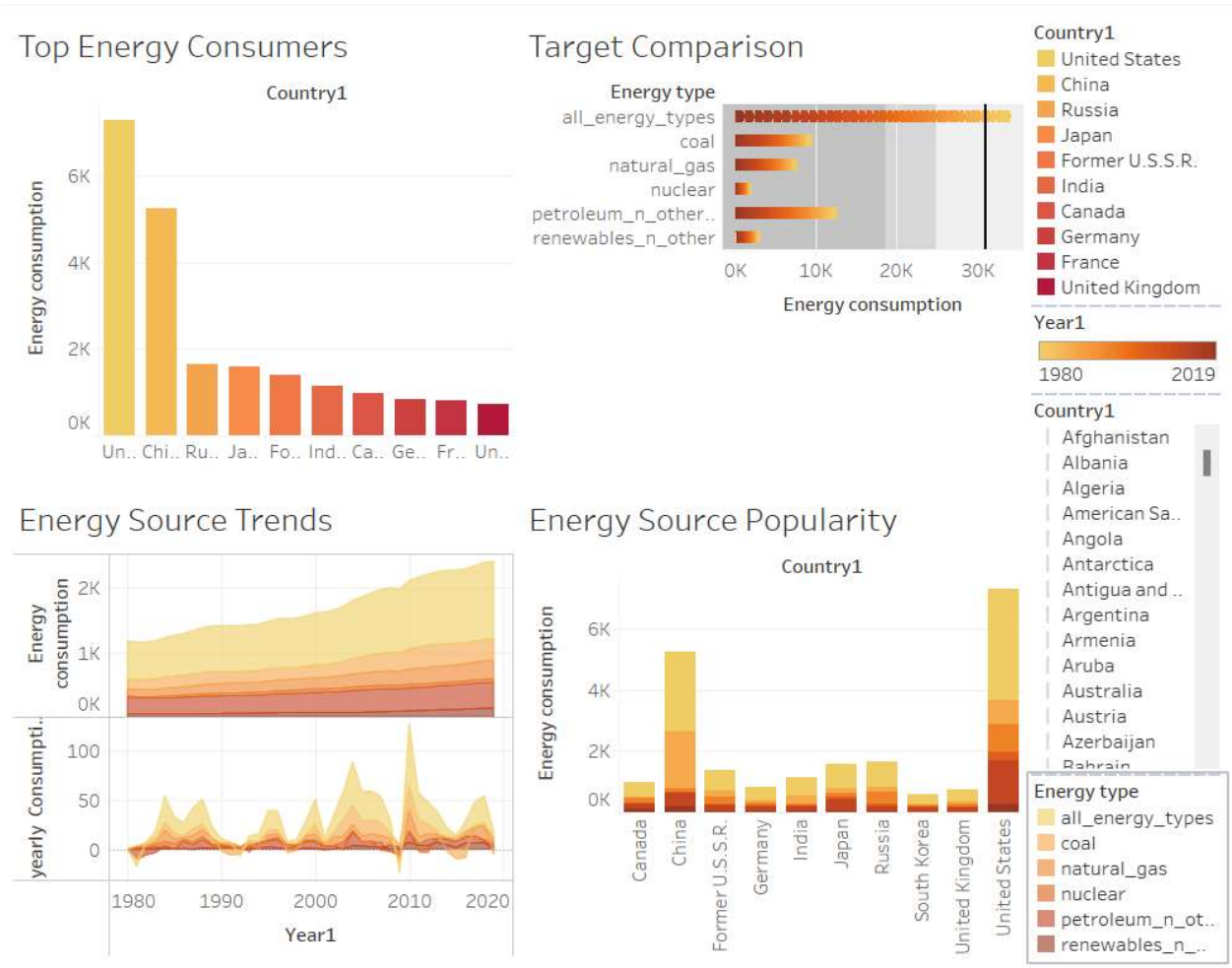

Fig 2 : Energy consumption

This dashboard offers a thorough analysis of global energy consumption patterns, with a particular focus on major countries such as the United States, China, India, Japan, and Russia. It examines their reliance on different energy sources, including fossil fuels, nuclear power, and renewable energy. The key observations drawn from the charts reveal that the United States and China are the two largest consumers of energy worldwide, driven by their massive economies, industrial activities, and large populations. China's energy consumption is predominantly fueled by coal and natural gas, reflecting its rapid industrial expansion and heavy reliance on fossil fuels. In contrast, the United States demonstrates a more diversified energy mix, with significant contributions from natural gas, petroleum, and an increasing share of renewable energy sources.

Globally, energy consumption has shown a consistent upward trend over several decades, driven by economic growth and population increases. Fossil fuels, particularly petroleum and natural gas, continue to dominate the global energy landscape, exhibiting strong and steady growth. Coal, while still a significant energy source, has experienced more gradual growth and is starting to show signs of decline in certain regions due to environmental policies aimed at reducing carbon emissions. On the other hand, nuclear energy and renewable sources like wind and solar power have also grown, though their share in the global energy mix remains comparatively smaller. Renewable energy, while gaining momentum, still lags behind fossil fuels in overall consumption, signaling the need for more accelerated adoption of cleaner energy sources.

The ongoing dominance of fossil fuels, despite the rise in nuclear and renewable energy, underscores the significant challenges that lie ahead in transitioning to more sustainable energy systems. This presents a formidable obstacle to achieving global sustainability and climate goals. The data highlights the importance of more aggressive efforts and international cooperation to expedite the shift away from fossil fuels and increase investments in cleaner, more sustainable energy alternatives to mitigate the environmental impact of energy consumption on a global scale.

CO2 Emissions across Countries

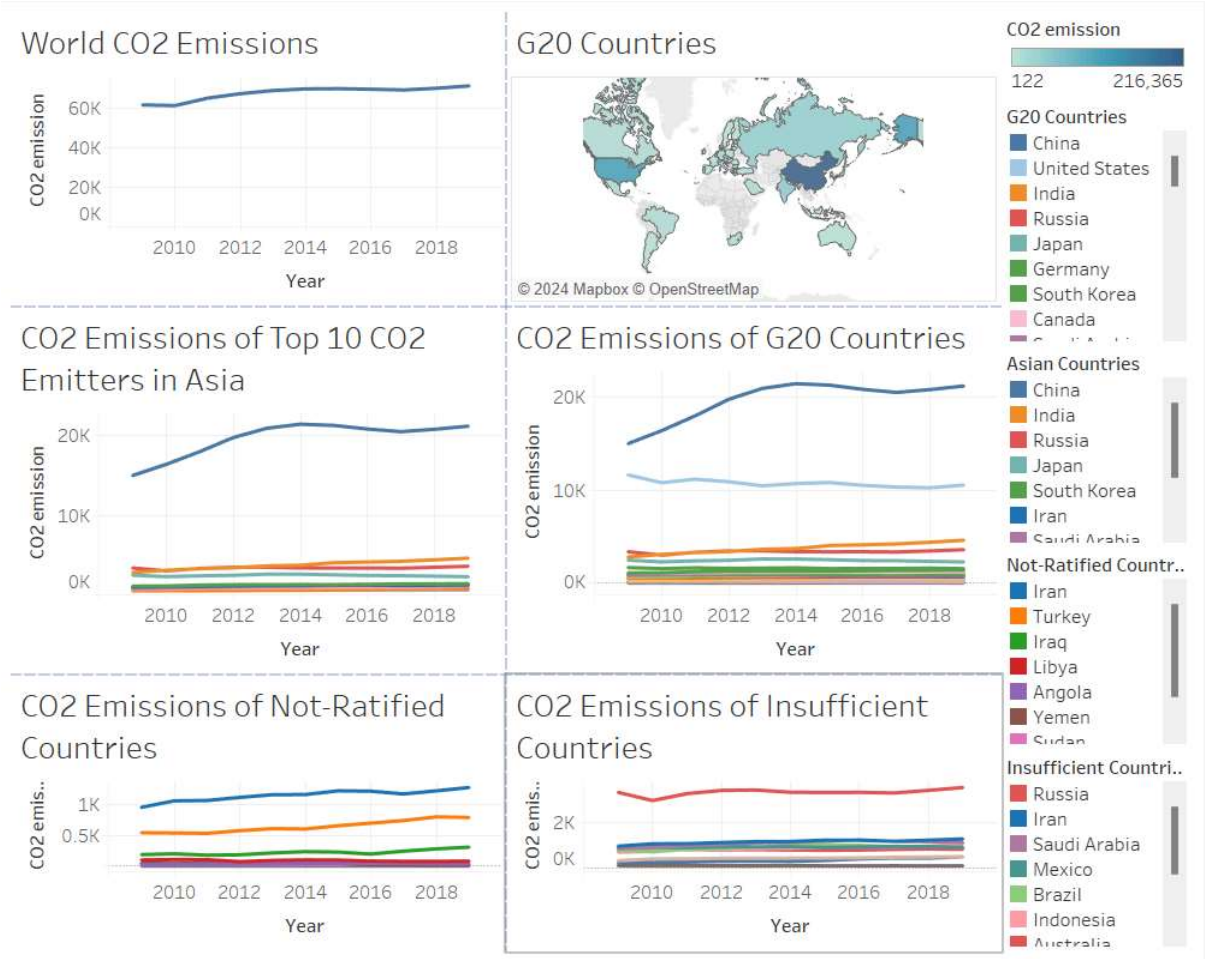

Fig 3 : CO2 Emissions across Countries.

For the top two graphs, we examined the top five countries with the highest CO2 emissions overall (China, US, India, Russia, and Japan). In doing so, the data points are more visible and eliminate less significant countries that could possibly skew the data.

Looking at the visualization between Energy Intensity by GDP vs Energy Intensity per capita, we observed both measures follow similar trends year to year with the exception of China. After 2013, China's Energy Intensity by GDP decreased while its Energy Intensity per capita continues to increase. Upon further research, we found this was a result of China's energy restructuring to increase production from its statewide power generators and reduce its reliance on coal. With the other countries' Energy Intensity by GDP and Energy Intensity per capita following parallel

trends, the graph reaffirms our hypothesis that GDP and population are contributing factors towards CO2 emissions.

The visualization between Population and GDP shows us there may not be a strong correlation between population and GDP themselves. Looking at the United States, it has the highest GDP in the world yet it has a significantly smaller population compared to China and India. From this graph, we can assume these disparities will lead to a difference in the correlation between CO2 emissions and population and the correlation between CO2 emissions and GDP.

In the bottom two graphs, we ran a linear regression on the correlation between CO2 emissions and population and the correlation between CO2 emissions and GDP. For both population and GDP, the p-values were less than 0.0001 and reaffirmed our hypothesis that they were statistically significant in contributing to CO2 emissions. The R-squared for CO2 emissions and GDP was 0.8693, which was higher than the R-squared between CO2 emissions and population of 0.6276. This answers our question as the CO2 emissions and GDP has a stronger correlation than the correlation between CO2 emissions and population. The implication of our findings suggests economic policies may have a stronger effect on reducing CO2 emissions than population control.

Global Trends in GDP, Population, and Energy Production

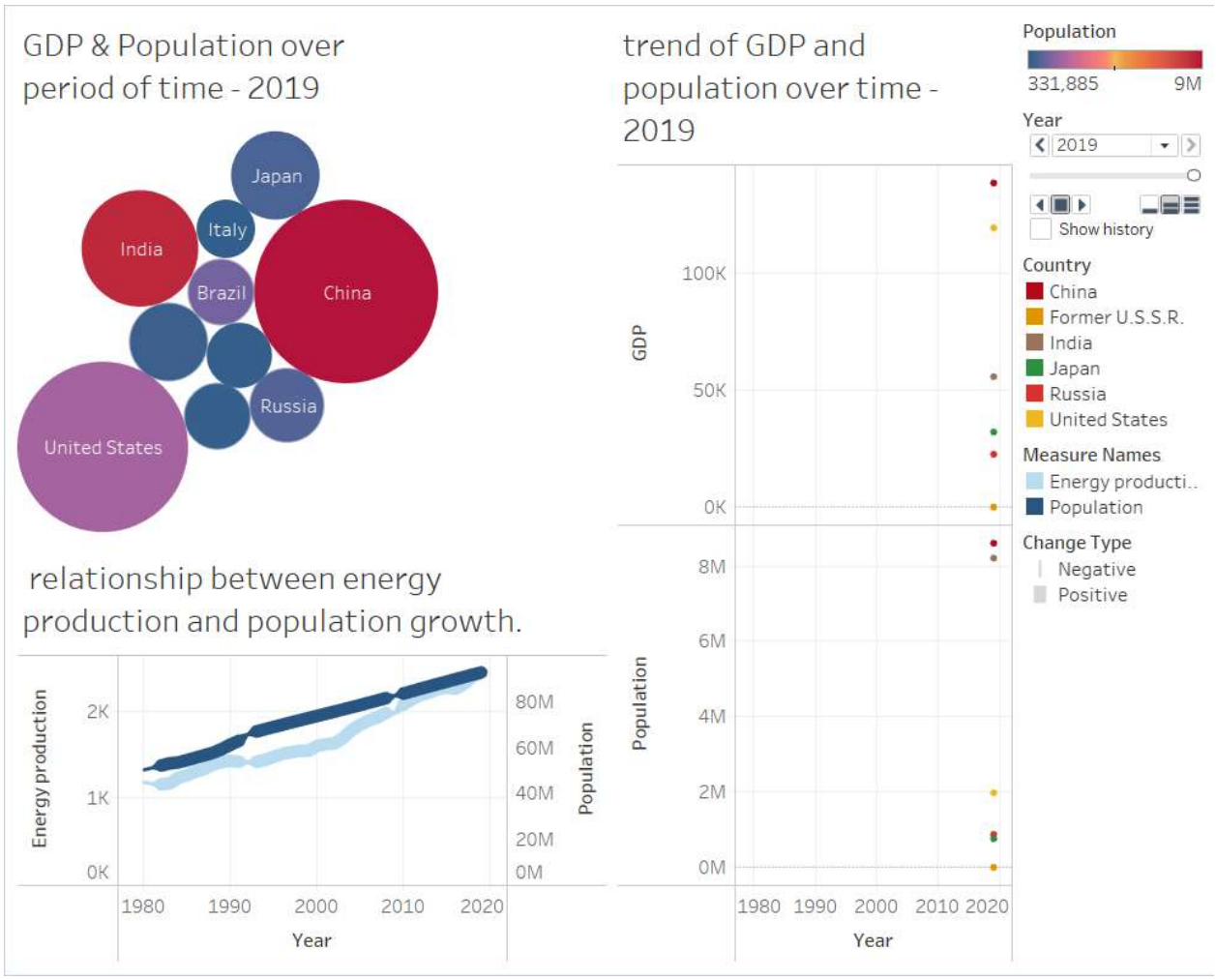

Fig 4: GDP , Population and Energy production

This dashboard visualizes the global relationships between GDP, population, and energy production across various countries, with a focus on data from 2019. The bubble chart on the left highlights the GDP and population sizes of major countries such as China, the United States, India, Japan, Russia, Italy, and Brazil. The size of the bubbles represents GDP, while the color gradient indicates population size, ranging from light (smaller populations) to darker hues (larger populations). China and the United States are notable for their significant GDP and population sizes.

The top-right scatter plot tracks the trend of GDP and population over time for these key countries, showing positive growth trends, with China's GDP and population leading globally. The color coding differentiates between positive and negative changes, illustrating consistent growth across all highlighted countries.

At the bottom, the line graph illustrates the relationship between energy production and population growth over time. As population increases, energy production also rises, indicating a direct correlation between the two. This trend underscores the ongoing challenge of scaling energy production to meet the demands of growing populations globally.

Energy Production and CO2 Emissions

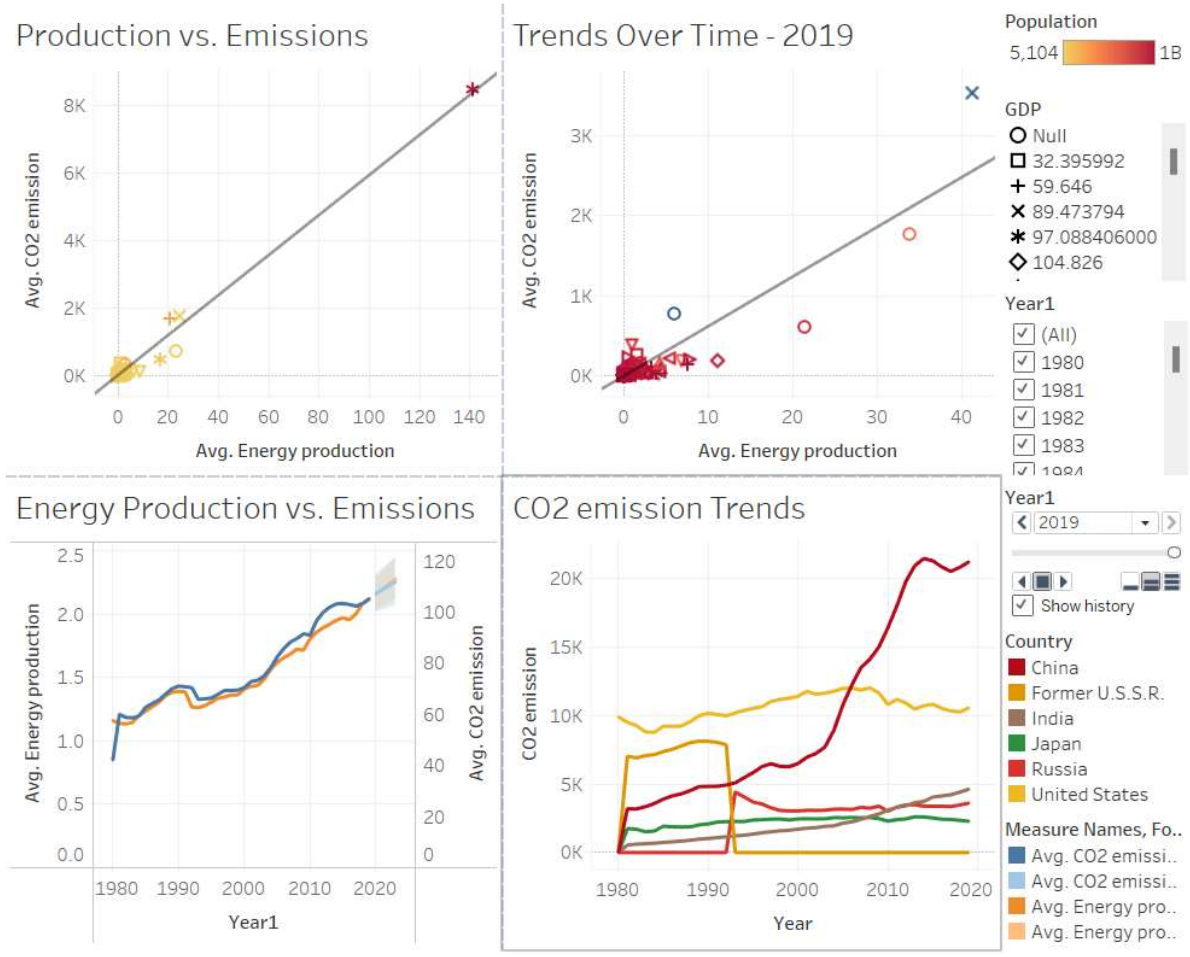

Fig 5 : Energy Production and CO2 Emissions

This dashboard visualizes the relationship between energy production and CO2 emissions across different countries and regions, analyzing historical data from 1980 and providing forecasts up to 2019. The top-left scatter plot shows a strong positive correlation between average energy production and CO2 emissions, with most countries falling along a diagonal reference line, indicating that higher energy production typically results in higher emissions. Notable outliers, such as China and the United States, demonstrate significantly high energy production and emissions, with some deviations suggesting potential use of cleaner technologies or higher

energy efficiency. The bottom-left line chart depicts parallel growth trends in global energy production and CO2 emissions over time, illustrating that both metrics have increased steadily since the early 2000s, with forecasts indicating further increases. However, the rate of increase is expected to stabilize slightly. The bottom-right line chart further breaks down CO2 emission trends by country, showing sharp rises in emissions for China, while other countries like the U.S. and India also contribute significantly. Overall, this data underscores the ongoing challenge of reducing CO2 emissions while meeting growing global energy demands, highlighting the urgent need for cleaner energy solutions to decouple production from emissions.

Conclusion

The analysis of global energy consumption and CO2 emissions reveals a critical intersection between economic growth, population size, and environmental sustainability. The data demonstrates that the largest energy consumers—China, the United States, and India—are also the top contributors to global CO2 emissions, driven by their expansive industrial activities and energy-intensive technologies. While renewable energy is gaining traction, fossil fuels continue to dominate the global energy mix, highlighting the challenges in transitioning to cleaner energy sources.

The correlation between energy consumption and CO2 emissions, particularly in high-GDP countries, emphasizes the need for aggressive policy interventions and international cooperation to mitigate environmental impacts. Economic growth, rather than population size alone, is a stronger predictor of CO2 emissions, suggesting that policies targeting energy efficiency and the adoption of sustainable energy technologies may be more effective in reducing global emissions than focusing on population control.

Ultimately, the ongoing upward trend in global energy consumption and emissions underscores the urgency of balancing economic development with sustainability goals. Without a significant shift towards cleaner energy and more efficient energy use, global efforts to combat climate change will continue to face substantial obstacles.