DATA VISUALIZATION

Final Project Report

Global Trends in Climate Impact: Analyzing Energy Production, Environmental Consequences, and Public Health Outcomes

Business Analytics and Information Systems

Submitted By

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Introduction

This project is dedicated to analyzing critical climatic factors and global energy production trends to understand their broader implications on environmental health and sustainable development. The analysis includes factors such as changes in surface temperatures, sea level rise, CO2 emissions, and the prevalence of asthma in relation to environmental conditions. It also examines the shift in energy production from non-renewable to renewable sources globally.

The data for this comprehensive analysis has been sourced from reputable and authoritative sources like World Bank, IRENA, Climate.gov etc. to ensure reliability and accuracy.

By integrating data from these established sources, the project aims to provide a robust foundation for understanding how climatic changes are interacting with energy production methods. The objective is to highlight the transitions in energy production methods from traditional fossil fuels to more sustainable alternatives such as wind, solar, and hydro energy. This transition is crucial for mitigating environmental impacts, particularly those contributing to climate change and public health issues.

Ambitiousness of the Project:

The analysis is intended to inform stakeholders, policymakers, and the public about the pressing need for adopting sustainable energy practices and the effects of environmental changes on public health. The overarching goal is to foster a deeper understanding of sustainable practices that can support global efforts in combating climate change effectively.

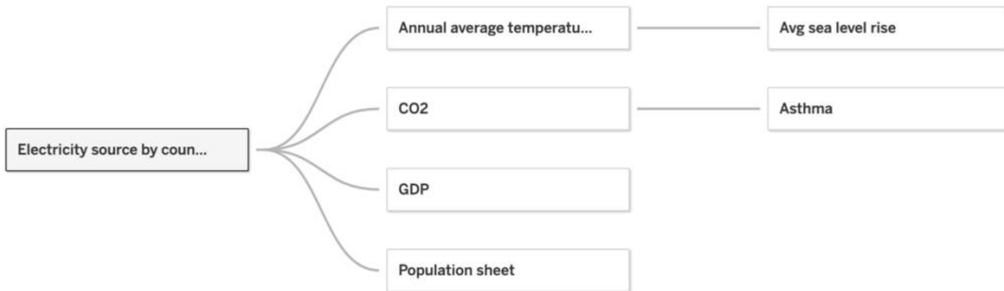
The project's **research questions** include:

1. How have global average temperatures and sea levels changed over the past two decades relative to baseline measurements, and what does this indicate about the immediate and long-term impacts of climate change?
2. What is the current distribution of CO_2 emissions on a global scale, and which countries are the highest and lowest contributors?
3. What are the relationships between energy production, environmental consequences, and public health outcomes as observed through the installed electricity capacity, CO_2 emissions, temperature increases, and the prevalence of asthma?
4. How have global and regional trends in the diversification of energy sources evolved over the past two decades, and what does this imply about the shift towards renewable energy adoption in comparison to non-renewable sources?
5. What is the relationship between a country's economic wealth, as measured by GDP, and its investment in renewable energy infrastructure, and how does this compare on a regional level when considering per capita renewable energy capacity?

Methodology

I have linked 7 datasets related to air pollution. The data sources include the Climate.gov, IRENA, Climate Copernicus, Our World in Data, and the World Bank. These datasets provide information about the CO_2 Emissions, Rise in Surface Temperatures and Sea Level Rise, Electricity Capacity and Generation, Asthma Prevalence, economic factors, and population. All 7 datasets are truly separate and cannot be merged into a single file.

Data sources



1. CO2_emissions_data:

https://data.worldbank.org/indicator/EN.ATM.CO2E.PC

This dataset provides information on CO2 emissions Value (metric tons per capita), Country and the data spans from 2000 to 2023.

2. Electricity Capacity and Generation:

https://www.irena.org/Data/View-data-by-topic/Capacity-and-Generation/Country-Rankings

This dataset provides comprehensive information on Electricity Installed Capacity (MW), including Region, Country, RE or Non-RE, Technology and year. The data spans from 2000 to 2023 and is sourced from the United Nations. It serves as a primary source for analyzing trends in Electricity Capacity and Generation.

3. sea level rise data

https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

This dataset provides information on Global Sea level according to UHSLC (mm) from 2000 to 2023.

4. Asthma Prevalence

https://ourworldindata.org/grapher/asthma-prevalence

This dataset shows current number of cases of asthma per 100 people, in both sexes in all the countries across the world from 2000 to 2023.

5. Annual average rise in temperature

https://cds.climate.copernicus.eu/cdsapp#!/search?type=dataset&text=ERA5%20monthly%20averaged%20data%20on%20single%20levels

This data depicts the average rise in temperature with respect to baseline temperature in all the countries from the year 2000 to 2023.

6. GDP:

https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country=

This shows the total GDP across different countries from the year 2011 to 2021.

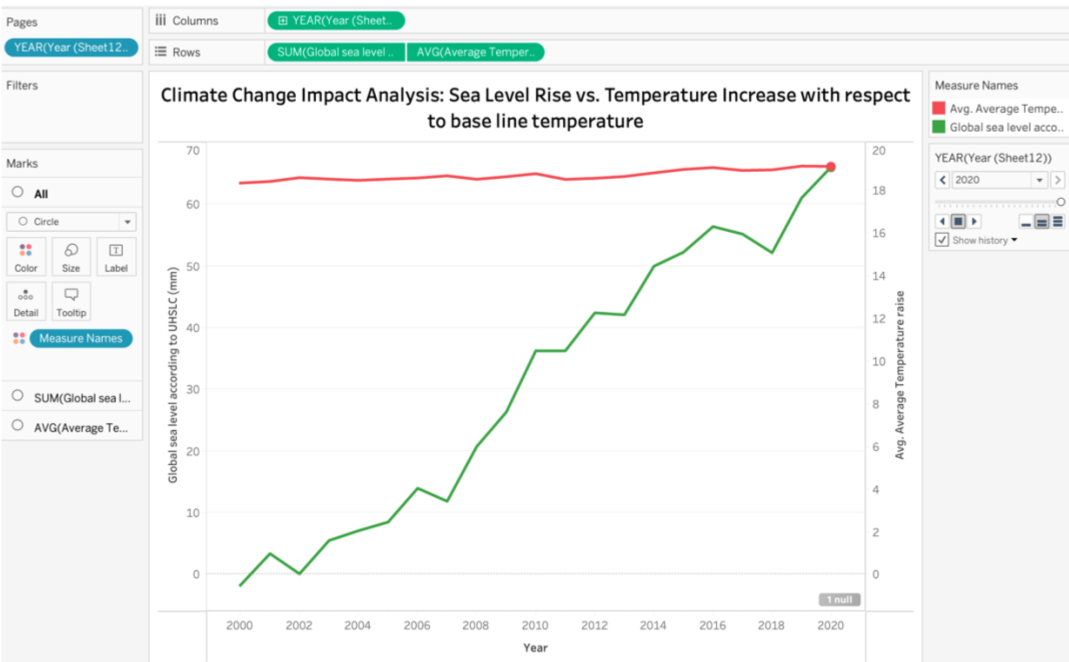
7. Population:

https://ourworldindata.org/grapher/population

This dataset contains Population data for various countries from 2000 to 2021 and is sourced from the Our World. Where Population data is a crucial component for normalizing various metrics, such as tourism expenditure, to enable per capita analyses that offer more meaningful comparisons between countries with different population sizes.

Analysis

1. Climate Change Impact Analysis: Sea Level Rise vs. Temperature Increase with respect to base line temperature



In this visualization the x-axis represents the years over the past two decades, while the dual y-axis depicts the global average temperatures relative to a baseline on one side and the average global sea level rise for the other. Based on the visualization, the past two decades have depicted significant shifts in global average temperatures and sea levels, each offering distinct insights into the impacts of climate change. While both temperature and sea level rise exhibit upward trends, the extent of their increase isn't necessarily proportional. Notably, despite a relatively stable trend in global average temperatures, the sea level rise graph illustrates a pronounced and consistent upward trajectory. This discrepancy suggests that factors beyond just temperature fluctuations contribute to sea level rise. The use of two separate line graphs with dual axes effectively captures these distinct measures, allowing for a clear comparison between global temperature trends and sea level rise over time. This approach enables viewers to discern the nuanced relationship between temperature and sea level, highlighting that while temperature stabilization may occur, the consequences of climate change, such as sea level rise, continue to persist and escalate.

tricity Installed Capacity per capita

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([Electricity Installed Capacity (MW)] / [Population]) * 1000
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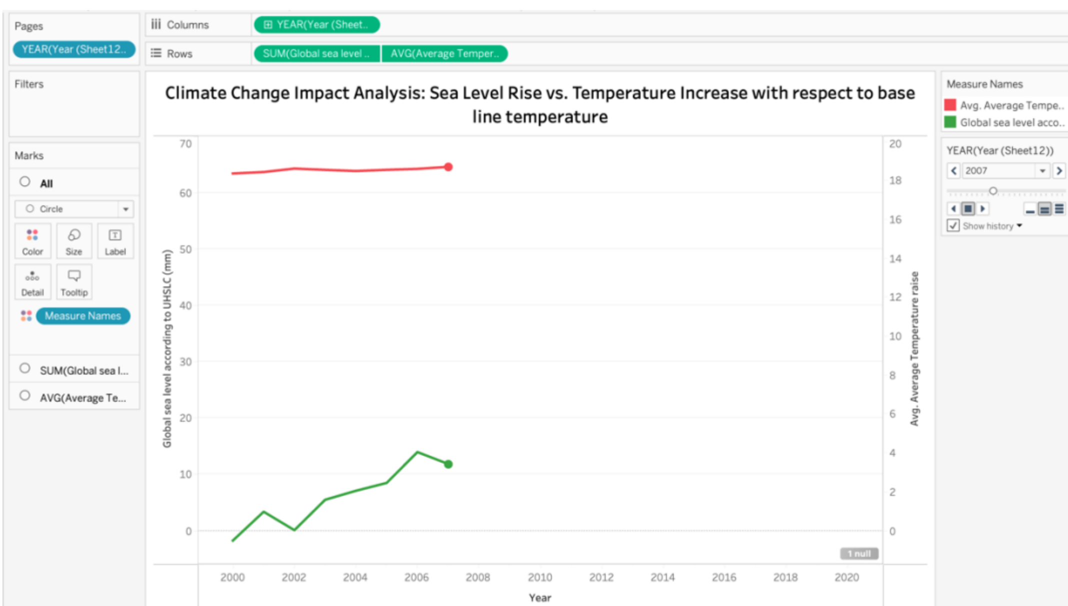
In this visualization, I've normalized the electricity installed capacity by population as the population varies across each country.



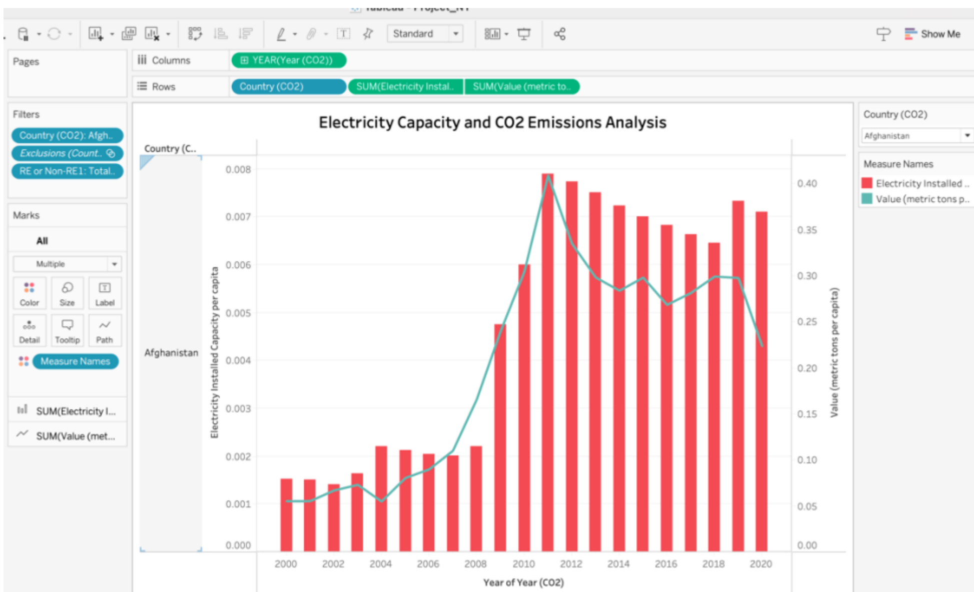
I've also developed an animated version of this visualization that displays the Avg. temperature rise with respect to baseline temperature and Global Sea level rise for each year sequentially. This answers my 1st research question.

2. CO2 Emissions Map: Global Carbon Footprint

This map visually represents the distribution of CO2 emissions per capita across various countries and regions. Areas shaded in red indicate regions where CO2 emissions per capita are relatively higher, such as Canada and Australia. In contrast, areas in green, including much of South America and Africa, show regions where CO2 emissions per capita are relatively lower. This visual differentiation highlights the disparity in carbon emissions across different parts of the world, emphasizing the varying levels of environmental impact or the differences in industrial, economic, and energy usage patterns among these regions. The map serves as a stark reminder of the unequal contributions to global carbon emissions and can be a critical tool in understanding where more intense efforts are required to reduce emissions and combat climate change. This map answers my second research question.

The following three visualizations explore changes in global average temperatures and sea levels over the past two decades compared to baseline measurements, which answers my 3rd research question.

3.Electricity Capacity and CO2 Emissions Analysis

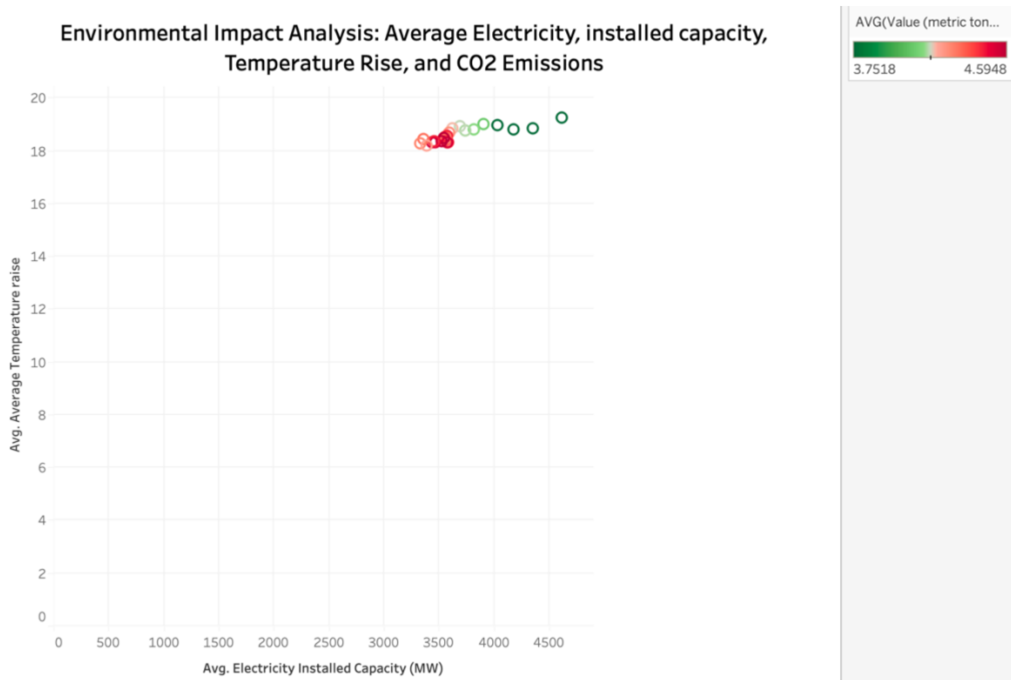


The visualization demonstrates the relationship between a country's electricity installed capacity and its CO2 emissions per capita. Interestingly, it reveals that there isn't always a direct correlation between an increase in electricity installed capacity and a rise in CO2 emissions per capita. Despite a notable surge in installed capacity for one year, the emissions per capita remained relatively stable. This suggests that advancements in electricity generation capacity can occur without a corresponding increase in CO2 emissions per person. It hints at the possibility of adopting more efficient or cleaner technologies, which could lead to sustainable energy development while mitigating environmental impact.

The use of a bar chart for electricity installed capacity per capita and a line chart for CO2 emissions per capita helps clarify these trends in a visually accessible manner.

I've also developed an animated version of this visualization that displays the electricity installed capacity and CO2 emissions for each year sequentially.

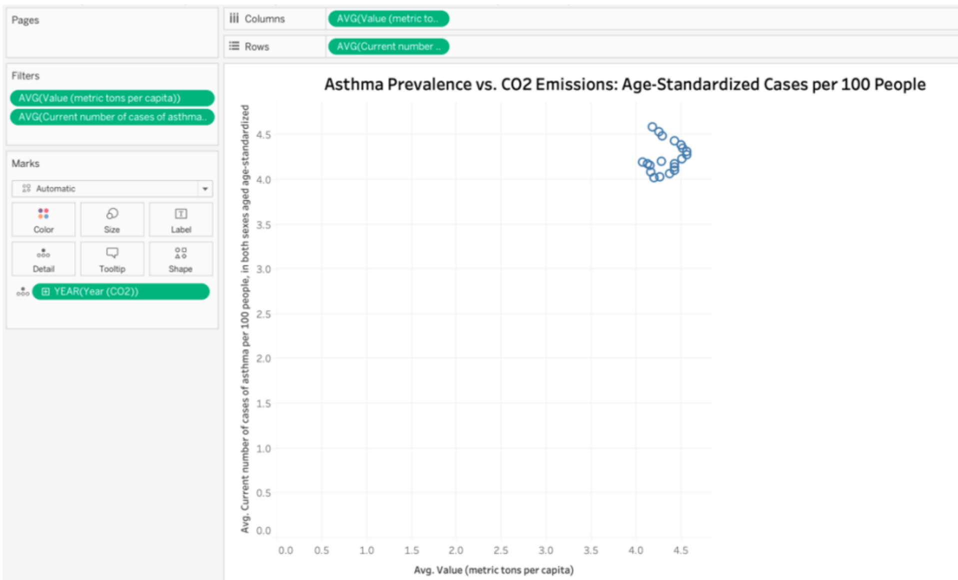
4.Environmental Impact Analysis: Average Electricity installed capacity, Temperature Rise, and CO2 Emissions



In this visualization, the x-axis represents the average electricity installed capacity (in Megawatts, MW) generated from non-renewable sources, while the y-axis shows the average temperature rise (degrees Celsius). Each point on the plot is colored to represent different years, with CO2 emissions per capita indicated by the color gradient from green to red, signifying lower to higher emissions respectively. I've used scatter plot as this best represents the relation between 3 measures.

The analysis reveals that while increased non-renewable energy capacity doesn't consistently correlate with rising temperatures, higher CO2 emissions per capita often align with greater electricity capacities. In the resent years, despite an increase in installed electricity capacity, per capita emissions reduced. This indicates that improvements in electricity generation can occur without a rise in CO_2 emissions per person, hinting at the potential for adopting cleaner and more efficient technologies.

5. Asthma Prevalence vs. CO2 Emissions: Age-Standardized Cases per 100 People

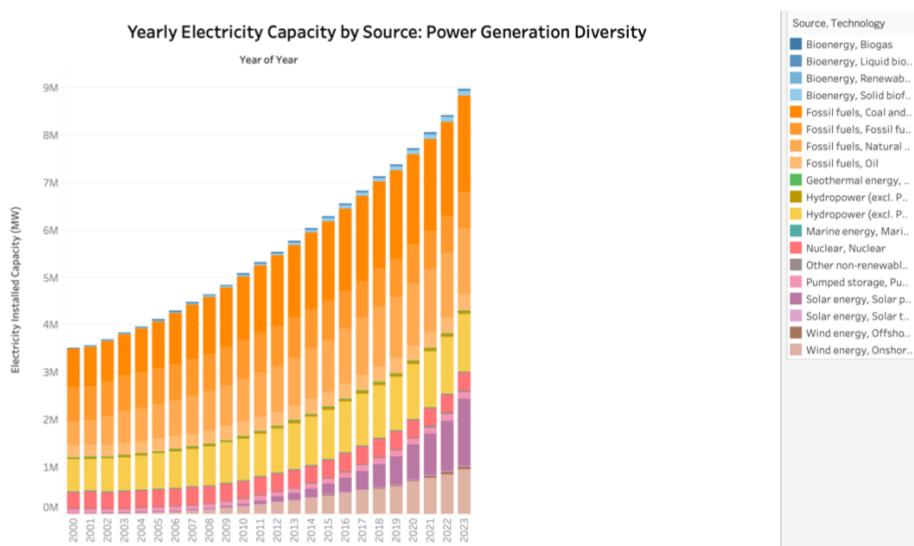


This visualization titled "Asthma Prevalence vs. CO2 Emissions: Age-Standardized Cases per 100 People" illustrates the relationship between CO_2 emissions (metric tons per capita) and the prevalence of asthma. Choosing a scatterplot to visualize this relationship is highly effective as this format clearly demonstrates the distribution and potential correlations, making it easier to identify trends and outliers in the data. Analyzing the plot, we observe a general trend where CO_2 emissions initially increase over the years and then begin to decrease, possibly reflecting the adoption of cleaner technologies and more efficient regulatory measures aimed at reducing carbon footprints.

Regarding the relationship between asthma prevalence and CO_2 emissions, the data points do not exhibit a clear or consistent pattern. This suggests that while CO_2 is a significant environmental concern, its direct correlation with asthma prevalence on a per capita basis may be influenced by other factors such as air quality, access to healthcare, and other environmental or genetic factors not captured solely by CO_2 metrics. This underscores the complexity of public health outcomes in relation to environmental pollutants and indicates the need for multi-faceted approaches to environmental health studies that consider various influencing factors beyond CO_2 emissions alone.

The next three visualizations examine the evolution of global and regional trends in energy source diversification over the past two decades. They provide insights into the shift towards renewable energy adoption relative to non-renewable sources. This is my 4th research question.

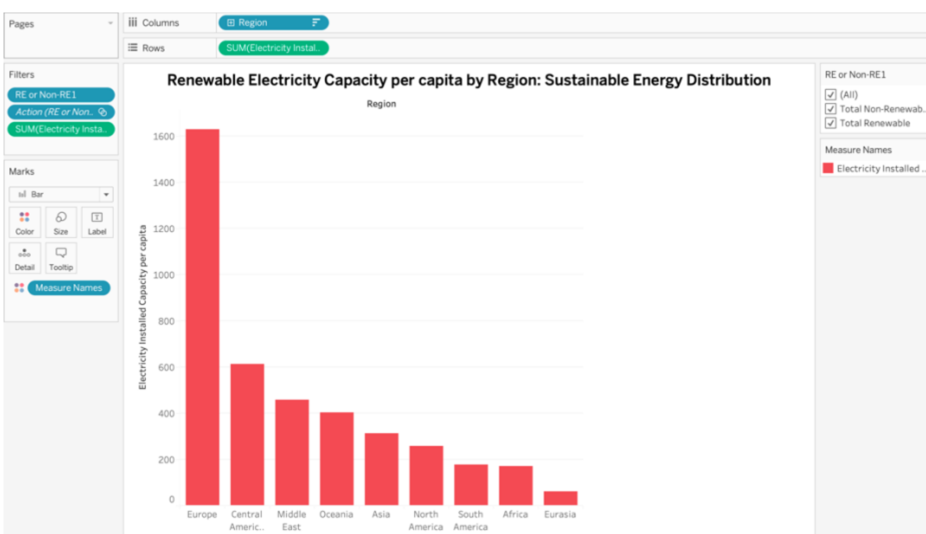
6.Yearly Electricity Capacity by Source: Power Generation Diversity



This visualization provides a comprehensive overview of the evolution of electricity capacity from various energy sources over a span of 23 years, from 2000 to 2023 with electricity installed capacity represented on y axis. This stacked bar chart format is particularly effective as it allows viewers to see not only the total installed capacity each year but also the contribution of each energy source to that total, facilitating a clear understanding of trends and shifts within the energy sector.

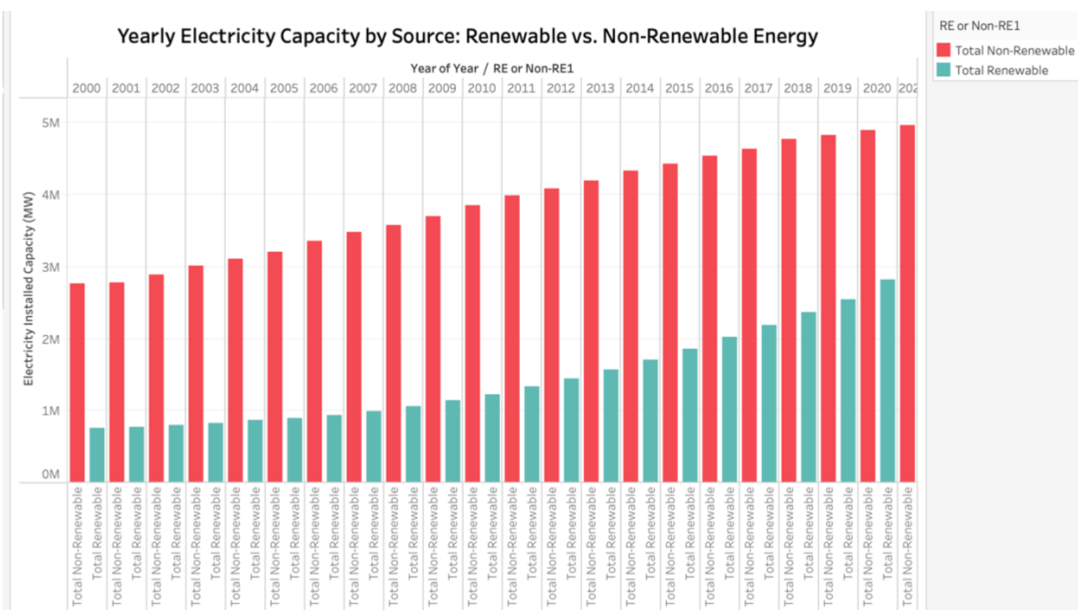
From this chart, there's a clear trend of increasing total installed capacity over the years, with a notable rise in the contributions from renewable energy sources such as solar and wind. This shift is indicative of global trends towards more sustainable energy solutions. The diverse color coding helps to easily distinguish between the various sources, showing how each contributes to the overall energy mix and the shift away from fossil fuels towards renewables over time. This visualization effectively communicates the progression of energy diversification as part of the global move towards sustainability.

7.Renewable Electricity Capacity per capita by Region: Sustainable Energy Distribution



This visualization provides a compelling overview of renewable electricity capacity per capita across different regions, with the capability to drill down into specific country-level data for more granular insights. Europe stands out as having the highest per capita renewable energy capacity, which underscores the effectiveness of its regional policies promoting sustainable energy. The use of bar graphs in this visualization is ideal because it allows for easy comparison across different regions, highlighting significant differences in energy capacity. The drill-down feature into country-specific data further enhances the utility of the visualization, making it possible to assess individual country performances within their respective regions and explore the impact of local policies on renewable energy adoption.

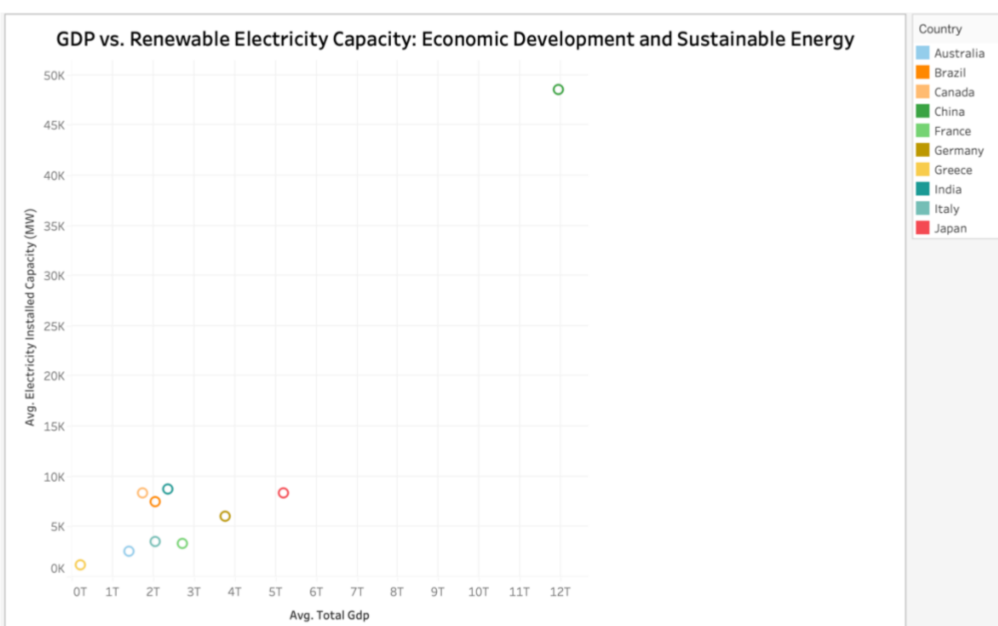
8.Yearly Electricity Capacity by Source: Renewable vs. Non-Renewable Energy



The visualization titled "Yearly Electricity Capacity by Source: Renewable vs. Non-Renewable Energy" offers a direct comparison between renewable and non-renewable energy sources across various years. Despite non-renewable sources dominating in terms of total installed capacity, the visual highlights a notable trend: the increasing prominence of renewable energy sources, as depicted by the growth of the green bars, particularly noticeable in the last decade. This gradual yet consistent rise in renewable capacity underscores a shift towards more sustainable energy sources. It reflects not only global environmental priorities but also the increasing feasibility and adoption of renewable technologies. The side-by-side chart format enables a direct comparison between renewable and non-renewable energy sources, facilitating the identification of trends in energy source diversification over time. This provides valuable insights into the transition towards renewable energy adoption and its environmental implications.

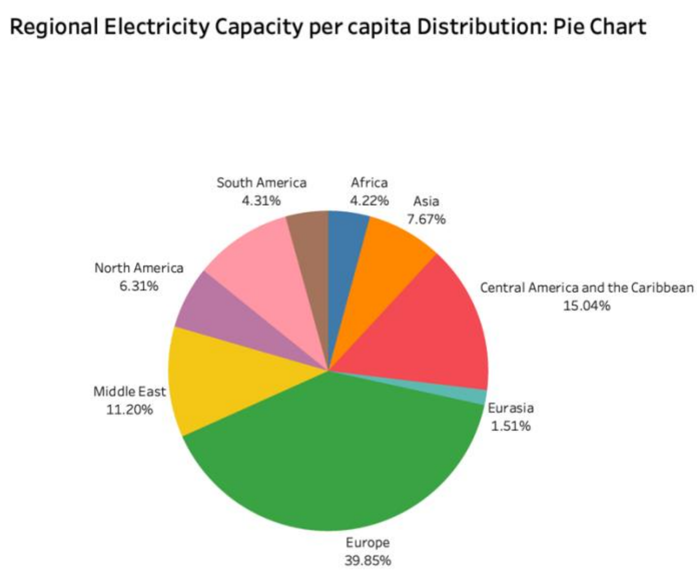
The next 2 visualizations explore the relationship between a country's economic wealth, as measured by GDP, and its investment in renewable energy infrastructure, which answers my 5th research question.

9.GDP vs. Renewable Electricity Capacity: Economic Development and Sustainable Energy



This scatterplot, illustrating the relationship between GDP and renewable electricity capacity per capita, highlights that economic wealth does not directly predict a country's investment in renewable energy. The visualization reveals a diverse spread where countries with similar GDP levels exhibit markedly different renewable capacity investments. For instance, nations like Italy and Brazil, despite having same GDP, show different investments in renewable energy, likely influenced by national policies and commitments to sustainable energy growth. This disparity emphasizes the complex interplay between a nation's economic status, political will, and environmental policies in shaping its renewable energy landscape. The choice of a scatterplot is particularly effective here as it allows for an immediate visual grasp of the correlation, or lack thereof, between these two variables across various countries, highlighting outliers and trends that merit further investigation.

10. Regional Electricity Capacity Per capita Distribution: Pie Chart

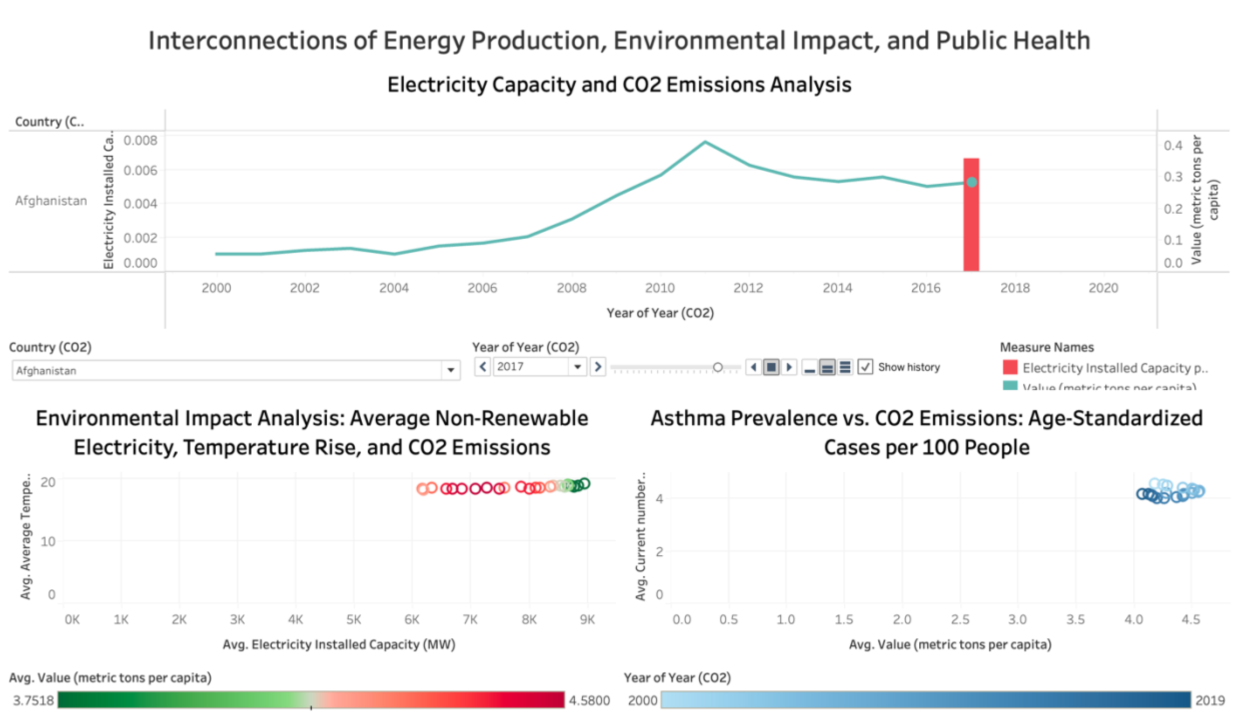


This pie chart provides a regional perspective, showing how renewable electricity capacity is distributed on a per capita basis across various regions. Europe's large portion of the pie chart signals a strong regional commitment to renewable energy, regardless of the individual GDPs of countries within that region. Other regions with significant economic wealth, such as North America, might have a smaller share of per capita renewable capacity, suggesting different regional priorities or stages in the transition to renewable energy.

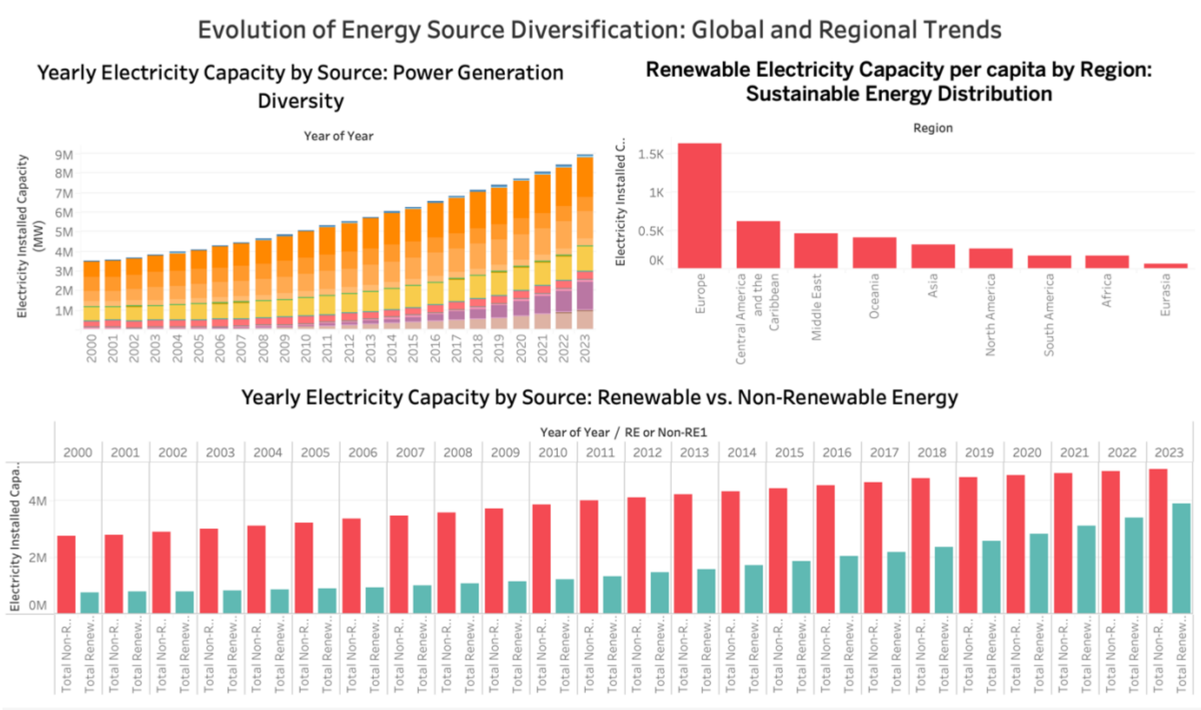
Dashboards

I have compiled and organized the data from various sources, including web scraping of visualizations, into comprehensive dashboards for efficient analysis and presentation of insights.

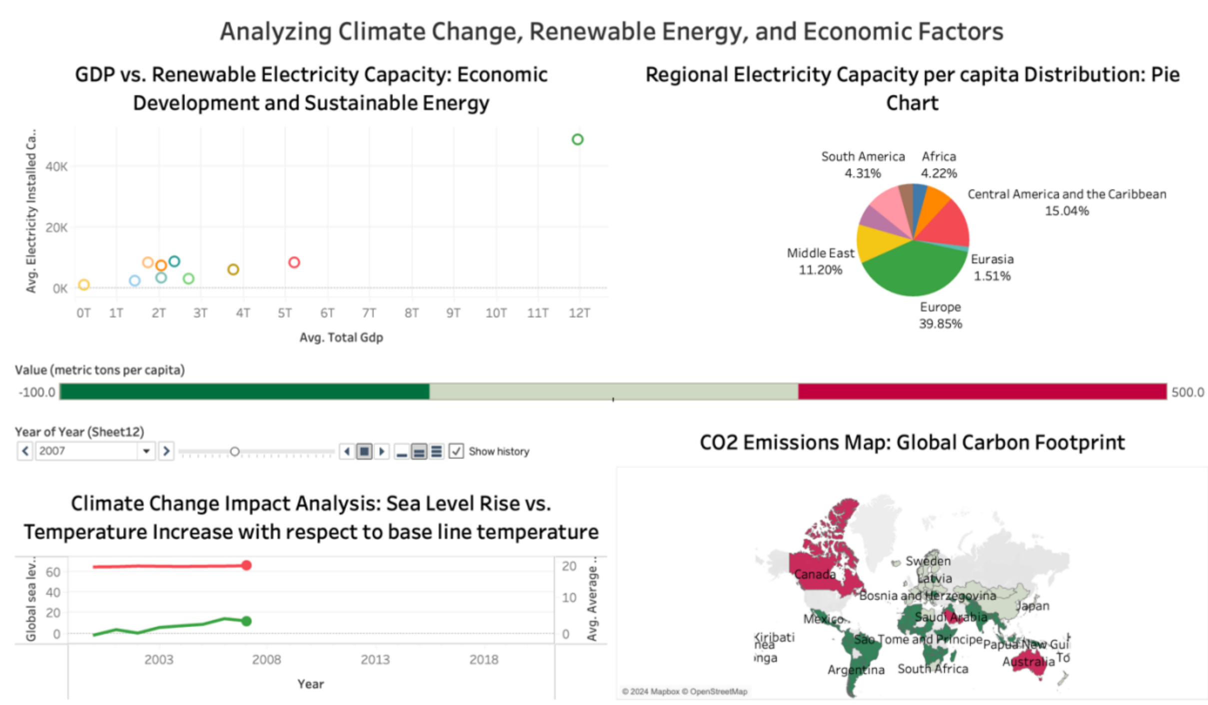
1.Interconnections of Energy Production, Environmental Impact, and Public Health



2.Evolution of Energy Source Diversification: Global and Regional Trends



3.Analyzing Climate Change, Renewable Energy, and Economic Factors



Conclusion:

The project's comprehensive analysis reveals crucial insights into the relationships between energy production, environmental impacts, and public health, highlighting the reality of climate change through significant changes in global temperatures and sea levels. It uncovers uneven CO_2 emissions across countries and shows a global shift towards renewable energy, though economic prosperity does not uniformly translate into renewable investment, underscoring the influence of national policies. These findings emphasize the need for global cooperation in energy policy to achieve sustainability goals, highlighting the critical role of governmental and international bodies in promoting renewable energy adoption for a healthier planet.

Research Questions Conclusion:

1. **Global Temperature and Sea Level Changes**: This demonstrates that while temperature trends stabilize, sea level rise persists, suggesting complex factors at play. This highlights the urgency of addressing climate change to mitigate its long-term effects on global environments and communities.
2. **CO_2 Emissions Distribution**: The analysis of global CO_2 emissions highlighted significant disparities among countries, with certain developed nations showing high emissions per capita, while others, particularly in developing regions, exhibited lower figures. This distribution underscores the need for targeted policies that address these inequalities in emissions and their impacts on global climate change.
3. **Energy Production, Environmental Consequences, and Public Health**: The relationship between energy production, environmental consequences, and public health outcomes

reveals nuanced interactions. While advancements in electricity generation can occur without a corresponding increase in CO2 emissions per capita, the alignment between higher CO2 emissions and greater electricity capacities underscores the environmental impact. However, the lack of a clear correlation between asthma prevalence and CO2 emissions suggests additional factors influencing public health outcomes.

4. **Diversification of Energy Sources**: Over the past two decades, there has been a noticeable global shift towards renewable energy sources. The visualizations clearly show an increase in renewable energy capacities across many regions, indicating a global trend towards sustainable energy practices. This shift is crucial for reducing dependence on non-renewable sources and mitigating environmental impacts.
5. **Economic Wealth vs. Renewable Energy Investment**: The study revealed that higher GDP does not necessarily equate to higher investments in renewable energy on a per capita basis. Countries exhibit varied commitment levels to renewable energy, influenced by national policies, economic priorities, and available resources. This insight is crucial for understanding the complexities of economic and environmental policy alignments across different regions.

Future Research Questions:

1. How do advancements in technology influence the efficiency of renewable energy sources, and what is their potential impact on reducing global CO2 emissions?
2. What adaptation strategies are most effective at mitigating the health impacts of climate change, particularly in regions highly vulnerable to extreme weather events?

3. How are shifts in global energy production affecting public health on a global scale, and what trends are anticipated with further changes in energy policies?
4. What are the impacts of large-scale renewable energy installations, such as solar farms and wind turbines, on local biodiversity and ecosystems?

Integrating these visualizations into broader strategic discussions can illuminate crucial insights within the project's analysis of climate and energy trends, uncovering previously overlooked information.