Visualization Analysis

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Summary Report

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**Declaration：**

I confirm that this assignment is my own work.

Where I/we have referred to academic sources, I have provided in-text citations and included the sources in the final reference list.

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# **Introduction**

## **Project Overview**

This project serves as a practical case study aimed at developing and applying Python programming skills, with a focus on data processing, database management, and data visualization. The project is based on a dataset related to renewable energy adoption, where key tasks include data import, cleaning, transformation, storage, visualization, and preliminary analysis.

For this project, I chose to develop the code within **Jupyter Notebook**, utilizing **Markdown** language to structure and document different sections of the workflow. This approach enhances code readability and ensures a clear and logical progression of tasks, making it easier to follow, execute, and reproduce the results.

The primary goal of this project is to enhance Python programming proficiency and gain hands-on experience with key libraries:

• **pandas** for efficient data manipulation and preprocessing, enabling data cleaning, transformation, and operations.

• **SQLite** for database storage and management, facilitating structured data organization and retrieval.

• **matplotlib** for data visualization, allowing trends and patterns to be effectively represented and interpreted.

By completing this project, I not only strengthened my data handling skills but also learned how to efficiently structure and present code within Jupyter Notebook, laying a solid foundation for data-driven programming applications in the future.

## **Objectives**

This project encompasses both programming skill development and practical data processing applications. The key objectives include:

• Data Import & Management: Efficiently load structured data from a CSV file using pandas and store it in an SQLite database for structured querying.

• Data Cleaning & Transformation: Identify and resolve missing values, adjust data types, and remove redundant columns to prepare data for analysis.

• Data Visualization: Use matplotlib to create multiple visualizations to illustrate trends clearly and facilitate data interpretation.

• Programming Proficiency: Develop a solid understanding of pandas, SQLite, and matplotlib while executing the entire data processing workflow within Jupyter Notebook.

• Notebook Code Organization & Optimization: Utilize Markdown language for step-by-step documentation, improving code structure, readability, and reproducibility.

• Database Operations: Use SQLite for data storage and querying, understanding the fundamentals of structured data management.

## **Scope of the Study**

Unlike a purely data analysis-focused study, this project primarily emphasizes Python programming techniques rather than in-depth statistical or economic research. The scope of the study includes:

• Automating Data Processing Workflows: Leveraging pandas to manipulate data efficiently, reducing manual processing.

• Database Management: Storing data in SQLite and performing SQL queries to filter and manage structured data.

• Code Structuring & Readability Enhancement: Organizing Notebook content using Markdown language, making the logic more intuitive and improving learning and reusability.

• Visualization & Presentation: Creating multiple charts (such as line plots, scatter plots, bar charts, and heatmaps) using matplotlib to better understand trends and patterns.

Although this project involves a renewable energy dataset, the main focus is not on energy policies or economic forecasting but rather on leveraging Python techniques to efficiently process, store, and visualize data. Additionally, by structuring the code within Jupyter Notebook, this project reinforces structured coding practices, enhancing the ability to write clear, well-documented, and logically organized code.

This hands-on project bridges the gap between theoretical programming knowledge and real-world applications, not only improving Python data processing skills but also fostering better code organization capabilities, ultimately preparing for future programming challenges.

# **2. Data Import and Database Creation**

## **2.1 Dataset Description**

The dataset used in this project contains **240 records** and provides renewable energy-related data for **10 major countries** from **2000 to 2023**. The key attributes in the dataset include:

• Total Energy Consumption (TWh) – The total energy consumption in terawatt-hours.

• Renewable Energy (%) – The proportion of renewable energy in total energy consumption.

• Government Investment (Million USD) – The amount of government investment in renewable energy in million USD.

• Emission Reduction (%) – The percentage reduction in emissions over time.

• Solar, Wind, Hydro, Geothermal, Biomass, and Other Renewables – Detailed breakdown of renewable energy sources used in each country.

**Handling Missing Values**

The dataset contains missing values in the following variables:

• Renewable Energy (%)

• Government Investment (Million USD)

• Solar, Wind, Hydro, Geothermal, Biomass, Other Renewables

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Each of these variables is missing **24 records**, meaning they contain only **216 complete entries** instead of the full **240 records**. This affects visualization accuracy and requires careful handling during data processing.

## **2.2 Data Sources**

The dataset was downloaded from the Kaplan VLE platform and provided by the FC724 teaching team as a case study for students to apply Python programming skills in data processing, database management, and visualization.

## **2.3 Database Setup**

To efficiently store and manage the dataset, an **SQLite database** was used. The database setup included **creating a connection**, **storing data**, and **retrieving information** from the database.

**2.3.1 Creating and Connecting to SQLite Database**

A SQLite database named "energy.db" was created, and a connection was established using the following command:

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This ensures that the database is ready for data storage and queries.

**2.3.2 Storing Data in SQLite Database**

The dataset was then stored in an **SQLite table** named "RenewableEnergy", replacing any existing table if it already existed:

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This process ensures that the data is **structured and easily retrievable** for further processing and visualization.

**2.3.3 Retrieving Table Names from Database**

To verify that the table was successfully created in the database, the available table names were retrieved:

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This step helps confirm that "RenewableEnergy" was properly stored in **SQLite**.

**2.3.4 Loading Data from Database**

Finally, the dataset was reloaded from the database into a **Pandas DataFrame** for further analysis:

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This ensures that the data stored in the database can be seamlessly used for **visualization and analysis** in later sections.

By implementing **SQLite database storage**, the dataset is managed in a **structured format**, allowing for **efficient querying, storage, and retrieval** of renewable energy data across different years and countries.

**3. Data Cleaning and Preprocessing**

In this section, the dataset underwent thorough cleaning and preprocessing to ensure consistency, accuracy, and completeness before analysis. The key tasks included identifying missing values, handling data imputation, adjusting data types, and removing redundant columns.

**3.1 Identifying Missing Values**

Before performing data analysis, it was crucial to assess missing values in the dataset to prevent inaccuracies in calculations and visualizations. The missing data was identified using the following command:

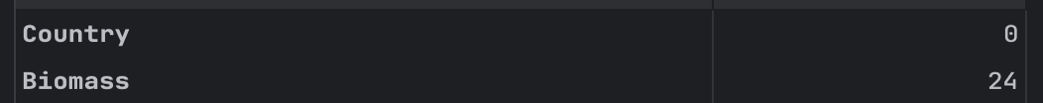
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**Code of Identifying Missing Values**

**Summary of Missing Data**

The dataset contained 240 records, but several varibles had missing values:

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**Output of Identifying Missing Values**

**3.2 Data Imputation Strategy**

To fill missing values, an appropriate strategy was selected based on the nature of each variable:

**3.2.1 Filling Missing Values in “Government Investment (Million USD)”**

Since government investment figures tend to have large variations and potential outliers, the **median value per country** was used to fill missing values:

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• Using the **median** instead of the mean **prevents distortions** caused by extreme investment values.

• Missing values were **replaced country-wise** to maintain regional economic consistency.

**3.2.2 Filling Missing Values in Other Numerical Columns**

For variables related to **Renewable Energy (%) and Energy Sources (Solar, Wind, Hydro, etc.)**, the **mean value per country** was used:

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• Using the **mean** ensures that missing values are filled with representative values **based on each country’s historical trends**.

• This method ensures **continuity in visualizations**.

**3.3 Validating Missing Values after Cleaning**

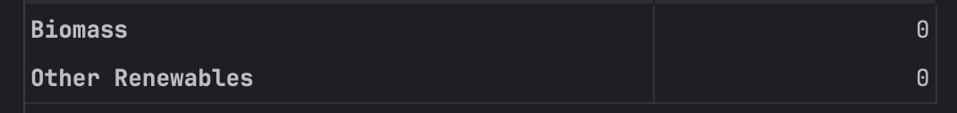
After handling missing values through **median and mean imputation**, it was essential to validate whether the missing values had been successfully addressed. This step ensured that the dataset was **fully complete** and ready for further analysis.

The following code was executed to check for any remaining missing values:

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**Code of Validating Missing Data**

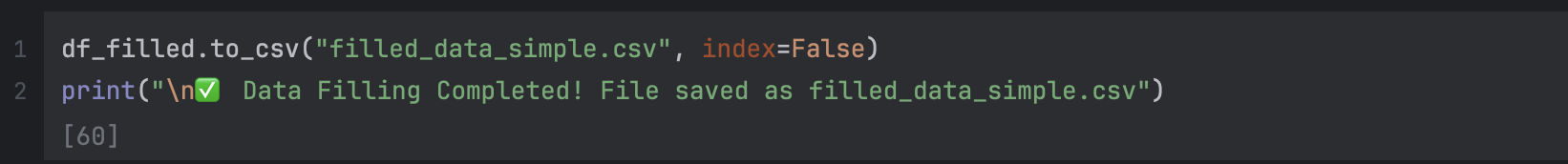
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**Output of Validating Missing Values**

**3.4 Exporting Cleaned Data for Analysis**

After cleaning, the dataset was saved for **further processing and visualization**:



**3.5 Storing Cleaned Data in SQLite Database**

To facilitate structured data management, the cleaned dataset was stored in an SQLite database:

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By storing the cleaned dataset in SQLite, data retrieval was streamlined for faster queries and efficient storage.

**4. Data Visualization and Analysis**

**4.1 Visualization 1：*Multi-Country Line Chart: Renewable Energy Trend Over Time***

**Overview**

This visualization presents the renewable energy adoption trends for 10 major countries from 2000 to 2023. Each subplot represents a country, illustrating the percentage of renewable energy in total energy consumption over time. The goal of this analysis is to identify the patterns, trends, and key shifts in renewable energy adoption across different nations.

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**Key Observations**

1. Most countries show a gradual increase in renewable energy adoption over time.

• Between 2000 and 2010, many countries had low and relatively stable renewable energy shares, with only minor fluctuations.   
• After 2010, a noticeable increase is observed in multiple countries, indicating a significant shift in energy policies or technological advancements.

2. China, the UK, and Japan show a particularly rapid increase after 2010.

• The trend lines for these countries display a sharp rise in renewable energy adoption after 2010, suggesting substantial policy support and investment in clean energy projects.

3. Fluctuations in the USA, Germany, and India indicate periods of rapid growth followed by stagnation or slight declines.

• The variations suggest that factors such as policy changes, economic conditions, or shifts in energy strategy might have influenced the trends.

4. A significant increase can be observed across almost all countries after 2020.

• This sudden rise may be attributed to enhanced government efforts, technological improvements, and stronger commitments to climate policies in response to global initiatives.

**Interpretation and Implications**

• The overall upward trend across multiple countries highlights the increasing role of renewable energy in global energy systems.   
• The sharp rise around 2010 and 2020 suggests that these years may be linked to significant international agreements, technological breakthroughs, or major policy shifts that have accelerated the transition to renewable energy.   
• Countries experiencing fluctuations (e.g., the USA, Germany, and India) may have faced policy or economic barriers that influenced the rate of adoption.

**Conclusion**

This analysis demonstrates that renewable energy adoption has generally increased over time, with significant surges around 2010 and 2020. While some countries exhibit steady growth, others show periods of stagnation or fluctuation, suggesting the influence of external factors. Further investigation is needed to determine the specific policies, global events, or economic conditions that may have triggered these trends.

**4.2 Visualization 2：*Multi-Country Line Chart: Emission Reduction Trend Over Time***

**Overview**

This visualization illustrates the carbon emission reduction trends for 10 major countries from 2000 to 2023. Each subplot represents a country, showing the percentage reduction in emissions over time. The objective of this analysis is to identify the patterns of emission reductions and understand potential factors driving these changes.

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**Key Observations**

1. Emission reductions remain relatively slow before 2010, with significant declines occurring post-2015.

• Many countries exhibit minimal or fluctuating reductions before 2010, suggesting that major policy efforts to curb emissions had not yet been widely implemented.

2. China, the USA, and India show substantial emission reductions after 2015.

• These three countries demonstrate a sharp downward trend, which could be linked to stronger environmental regulations, increased renewable energy adoption, and industrial reforms.

3. Germany, the UK, and Canada exhibit a steady and sustained reduction over the years.

• Unlike countries with abrupt declines, these nations show consistent progress in emission reductions, likely due to long-term climate strategies, regulatory measures, and renewable energy transitions.

4. Brazil, Japan, and South Africa experience fluctuations in emission reductions.

• These variations may be caused by economic cycles, industrial shifts, or changes in fossil fuel dependence.

5. A sharp decline in emissions is observed across multiple countries after 2020.

• This could be attributed to COVID-19 pandemic-related economic slowdowns, stronger climate policies, and increased investments in sustainable energy solutions.  
Interpretation and Implications   
• Countries with stable and continuous emission reductions (e.g., Germany, UK, and Canada) likely have well-established climate policies that ensure long-term progress.   
• The post-2015 and post-2020 reductions indicate that major policy interventions, international agreements, and economic shifts have played a crucial role in lowering emissions.   
• Fluctuating reductions in certain countries suggest that economic and policy instability can impact the effectiveness of emission reduction efforts.

**Conclusion**

This analysis highlights the global progress in emission reductions, particularly after 2015 and 2020, reinforcing the importance of policy interventions and clean energy transitions. While some countries have achieved stable and continuous reductions, others still experience variability, suggesting that additional structural and regulatory measures are needed to sustain long-term emission reductions.

**4.3 Visualization 3：*Scatter Plot with Regression: Renewable Energy Share vs. Emissions Reduction***

**Overview**

This analysis explores the relationship between renewable energy adoption and emission reduction across 10 major countries.

• X-axis: Percentage of renewable energy in total energy consumption.   
• Y-axis: Percentage reduction in carbon emissions.   
• Blue dots represent individual data points for each year, while the red regression line (with confidence intervals) indicates the overall trend.

Additionally, a correlation analysis was performed, calculating slope, intercept, R-value (correlation coefficient), and p-value to determine the strength and significance of the relationship between these two variables.

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**Key Findings from the Scatter Plot and Regression Analysis**

1. A strong positive correlation is observed between renewable energy adoption and emission reduction.

• Most countries exhibit a clear upward trend, indicating that higher renewable energy adoption is strongly associated with greater emission reductions.

2. The UK, China, and Japan demonstrate the strongest relationships.

• With R-values above 0.90, these countries show that increased renewable energy adoption has been highly effective in lowering emissions.

3. Germany, Brazil, and India also display strong correlations.

• Their transition to renewable energy appears to be a key factor in their emission reduction strategies.

4. The USA, Canada, and South Africa show relatively weaker correlations.

• While renewable energy adoption still contributes to emission reductions, these countries may also rely on other emission reduction strategies, such as energy efficiency improvements or industrial shifts.

5. Statistical analysis confirms the significance of the relationship.

• The low p-values (< 10⁻⁶) indicate that the observed correlations are statistically significant, reinforcing the argument that expanding renewable energy is an effective way to cut emissions.  
Interpretation and Implications   
• Countries that have prioritized renewable energy expansion have seen substantial reductions in emissions, validating the effectiveness of clean energy policies.   
• Countries with weaker correlations may need to complement renewable energy adoption with additional measures, such as stricter emission regulations, energy efficiency improvements, or industrial transformation policies.   
• Given the strong statistical evidence, governments should prioritize increasing renewable energy investment and implementation to achieve their climate goals.

**Conclusion**

This analysis provides clear empirical evidence that higher renewable energy adoption leads to significant emission reductions. Countries that have made strong commitments to clean energy have achieved greater success in reducing emissions, reinforcing the need for continued expansion of renewable energy sources to accelerate global decarbonization efforts. Future policies should focus on scaling up renewable energy projects, enhancing energy storage technologies, and integrating clean energy into national power grids to maximize emission reduction potential.

**4.4 Visualization 4：*Heatmap: Global Renewable Energy Adoption Trends (2000-2023)***

**Overview**

This heatmap visualizes the renewable energy adoption trends across 10 major countries from 2000 to 2023.

• The x-axis represents the years (2000-2023), while the y-axis lists the countries.   
• The color gradient indicates the percentage of renewable energy in total energy consumption, with lighter colors representing lower adoption rates and darker colors representing higher adoption rates.   
• The goal of this visualization is to identify key periods of change and significant trends in renewable energy adoption over the past two decades.

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**Key Observations**

1. 2010 marks a turning point in renewable energy adoption.

• Before 2010, most countries had very low renewable energy shares (light-colored areas dominate the heatmap).   
• After 2010, a significant increase in renewable energy adoption is observed across multiple countries, with darker shades appearing.   
• This suggests that global or national policy changes, technological advancements, or financial incentives around this time may have played a crucial role.

2. A second major surge occurs around 2020.

• Between 2019 and 2023, renewable energy adoption accelerates rapidly in nearly all countries, as indicated by the widespread dark blue areas.   
• The shift suggests that global climate policies, net-zero commitments, and post-pandemic economic recovery plans may have contributed to this rapid increase.

3. China, Germany, and the UK lead in renewable energy adoption.

• These countries display the darkest shades by 2023, indicating a high percentage of renewable energy in their total energy consumption.   
• The trend suggests strong policy support, continuous investments, and aggressive renewable energy expansion strategies.

4. Developing countries show a slower but consistent upward trend.

• India, Brazil, and South Africa started with very low renewable energy shares but have shown steady progress.   
• These countries are gradually transitioning toward renewables but may still face challenges related to infrastructure, policy execution, or economic constraints.

**Interpretation and Implications**

• The turning points in 2010 and 2020 indicate the potential influence of global climate agreements, regulatory changes, and economic shifts.   
• 2010: Possible factors include the rise of renewable energy subsidies, advancements in solar and wind technology, and international commitments such as the Copenhagen Accord (2009).   
• 2020: This period aligns with increased focus on net-zero targets, the European Green Deal, and economic recovery plans post-COVID-19, many of which emphasized clean energy investments.   
• Countries with sustained growth, such as Germany, China, and the UK, may have benefited from early policy interventions and consistent government support.   
• Developing nations are still catching up, suggesting a need for further policy incentives, financial mechanisms, and technology transfer to accelerate renewable energy adoption.

**Conclusion**

The two major turning points in 2010 and 2020 highlight the role of global agreements, economic policies, and technological advancements in driving renewable energy growth. Moving forward, sustained policy efforts, international collaboration, and infrastructure investment will be crucial for ensuring a global transition to cleaner energy sources.

**4.5 Visualization 5：*Stacked Bar Chart: Renewable Energy Composition by Country***

**Overview**

This stacked bar chart illustrates the composition of renewable energy sources in 10 major countries from 2000 to 2023. Each bar represents a country, and the different colors denote various renewable energy sources, including:

• Solar (dark purple)   
• Wind (blue)   
• Hydro (dark green)   
• Geothermal (green)   
• Biomass (yellow)

The percentage values indicate the share of each renewable energy source in the total renewable energy mix for each country. The objective is to identify which countries rely more on specific energy sources and where there might be gaps in diversification.

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**Key Observations**

1. China and Germany are heavily reliant on wind and solar.

• China: Wind (26.1%) and Solar (17.3%) make up nearly half of its renewable energy composition.   
• Germany: The largest share comes from Solar (26.5%) and Wind (22.1%), indicating a strong push for distributed renewable energy generation.   
• Both countries have relatively lower contributions from hydro and geothermal energy, highlighting a focus on wind and solar expansion.

2. Brazil and Canada are dominated by hydro energy.

• Brazil (24.2%) and Canada (22.2%) have hydro as their largest renewable source, demonstrating a strong reliance on large-scale hydroelectric projects.   
• Solar and wind have smaller shares, indicating a need for diversification in their renewable energy portfolios.

3. The UK and South Africa have the highest wind energy shares.

• The UK’s renewable energy mix is dominated by wind (26.6%), reinforcing its investment in offshore wind projects.   
• South Africa follows closely with 26.6% wind share, though its energy mix remains relatively balanced compared to other countries.

4. India and Australia display a more balanced mix of renewable sources.

• India has contributions from wind (20.9%), hydro (24.9%), and solar (18.2%), indicating a diversified renewable energy strategy.   
• Australia has a relatively even mix of solar (18.7%) and biomass (18.6%), demonstrating a broad approach to renewable energy adoption.  
Interpretation and Implications   
• Countries like China and Germany are prioritizing wind and solar, whereas Brazil and Canada remain dependent on hydro.   
• Diversification is key to energy security—countries overly reliant on a single renewable source may face supply risks due to seasonal or environmental factors.   
• Wind energy plays a leading role in the UK and South Africa, emphasizing the importance of offshore and land-based wind projects.

**Conclusion**

This analysis reveals clear differences in renewable energy strategies across countries. Some nations focus on specific energy sources, while others develop a more balanced mix. Future strategies should emphasize diversification, ensuring that renewable energy adoption is sustainable, reliable, and adaptable to changing conditions.

**4.6 Visualization 6：*Scatter Plot with Regression Line: Government Investment vs Renewable Energy Share***

**Overview**

This visualization and regression analysis examine the relationship between government investment in renewable energy (Million USD) and the percentage of renewable energy share in total energy consumption across 10 major countries.

• The scatter plot displays individual data points, where:

• X-axis: Government investment in renewable energy (Million USD).   
• Y-axis: Renewable energy share (%).   
• The regression line (with confidence intervals) represents the trend between these two variables. • The statistical table provides insight into the correlation coefficient (R-value), slope, and significance (P-value).

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**Key Findings from the Scatter Plot and Regression Analysis**

1. Weak or negative correlation between government investment and renewable energy share.

• Germany (-0.327), Australia (-0.248), and China (-0.091) show negative correlations, suggesting that higher investment does not necessarily result in higher renewable energy adoption.   
• Even countries with positive slopes (Brazil, UK, and USA) have low R-values (below 0.35), indicating that government spending alone is not a strong predictor of renewable energy adoption.

2. High investment does not guarantee high renewable energy adoption.   
• Countries with high investments (e.g., China, Germany, and Australia) do not exhibit a strong upward trend in renewable energy adoption.   
• Some countries with moderate investments (e.g., Brazil, UK) show better adoption rates, implying that factors beyond investment influence growth.

**Conclusion**

This analysis challenges the assumption that higher government investment directly leads to greater renewable energy adoption. Instead, it highlights that policy effectiveness, infrastructure readiness, and market mechanisms play a more critical role in driving clean energy transitions. Future efforts should focus on comprehensive policy strategies rather than relying solely on financial investments.

**5. Key Findings and Insights**

This section summarizes the key insights derived from the data analysis and visualization of renewable energy adoption and emission reduction trends across 10 major countries from 2000 to 2023. The findings focus on patterns, policy impacts, and the relationship between renewable energy expansion and emission reduction.

**5.1 Patterns and Trends**

**1. Global Growth with Key Turning Points in 2010 and 2020**

• Renewable energy adoption has steadily increased worldwide, with two major surges occurring around 2010 and 2020.

• 2010 marked the beginning of rapid growth, likely influenced by technological advancements, financial incentives, and international climate agreements.

• 2020 saw an even more significant surge, potentially linked to net-zero commitments, the European Green Deal, and post-COVID-19 economic recovery plans that prioritized green investments.

**2. Diverse Growth Patterns Across Countries**

• China, the UK, and Japan experienced the fastest adoption rates post-2010, showing a sharp increase in renewable energy share.

• Germany, the USA, and India exhibited fluctuations, with periods of rapid growth followed by stagnation or minor declines, likely due to policy shifts, economic conditions, or energy strategy adjustments.

• Brazil, Australia, and Canada showed stable but moderate growth, indicating a steady transition towards renewables without major fluctuations.

**3. Renewable Energy Composition Differs Across Countries**

• China and Germany rely heavily on solar and wind power, reflecting large-scale government investments in these sectors.

• Brazil and Canada remain hydro-dominant, suggesting long-standing reliance on large-scale hydropower projects with less emphasis on diversifying into wind and solar.

• The UK and South Africa lead in wind energy usage, particularly benefiting from offshore wind projects.

• India and Australia exhibit a balanced mix, incorporating solar, wind, and hydro at similar proportions.

**5.2 Impact of Government Investment**

**1. Weak Correlation Between Investment and Adoption Rates**

• Despite high government investments in renewable energy, the correlation between funding and actual adoption rates is weak across most countries.

• Countries like Germany, Australia, and China even show a negative correlation, suggesting that increased investment does not necessarily translate into higher renewable energy share.

**2. Policy and Infrastructure Play a More Crucial Role Than Investment Alone**

• The data suggests that financial support alone is insufficient; other factors such as policy effectiveness, regulatory frameworks, infrastructure development, and market readiness play a more decisive role in renewable energy adoption.

• Countries with strong, long-term energy policies (e.g., the UK, Germany, and China) have successfully scaled up renewable energy, despite varying investment levels.

• In contrast, countries with inconsistent policies or infrastructure challenges struggle to translate investment into adoption.

**5.3 Relationship Between Renewable Energy and Emission Reduction**

**1. Strong Positive Correlation Between Renewable Energy Growth and Emission Reduction**

• Countries with higher renewable energy adoption rates have significantly reduced their emissions over time.

• The strongest correlations are observed in the UK, China, Japan, Germany, Brazil, and India, indicating that increasing renewable energy usage has been highly effective in cutting emissions.

• Countries like the USA, Canada, and South Africa show relatively weaker correlations, suggesting that emission reduction in these nations may also be influenced by industrial shifts, efficiency improvements, or other regulatory measures beyond renewable energy adoption.

**2. Major Declines in Emissions After 2015 and 2020**

• Post-2015 emission reductions align with the implementation of the Paris Agreement and increased global commitments to carbon neutrality.

• Post-2020 reductions may be linked to COVID-19-induced economic slowdowns, combined with stronger global policy initiatives promoting decarbonization.

• Countries like China, the USA, and India show the most significant reductions after 2015, likely due to a combination of renewable energy expansion, policy interventions, and industrial restructuring.

**3. The Role of Policy and Market Mechanisms in Driving Emission Reduction**

• Countries with stable and continuous emission reduction trends (e.g., Germany, UK, and Canada) likely benefit from well-established climate policies that drive sustained progress.

• Fluctuating emission reduction patterns in countries like Brazil, Japan, and South Africa suggest that policy inconsistencies, economic cycles, or industrial dependencies impact emission trends.

• The data reinforces that scaling up renewable energy adoption is a highly effective strategy for long-term emission reduction but should be complemented with stronger regulations, energy efficiency improvements, and industrial reforms.

**6. Reflective**

This section reflects on the personal learning experience, challenges faced, skills developed, and areas for improvement throughout this project. As my first hands-on experience with Python for data analysis and database management, this project has provided me with a valuable opportunity to apply programming, data processing, and visualization techniques in a structured manner.

**6.1 Personal Learning Experience**

**1. First Attempt at Python for Data Analysis & SQL Database Usage**

• This project was my first attempt at using Python for data analysis and SQL databases for data storage and organization.

• I have always been interested in data analysis, and I believe it will play a crucial role in my future career in business applications of technology.

• Through this project, I have gained a fundamental understanding of how to use Python for data processing, how to manage structured data using SQLite, and how to visualize trends effectively.

**2. Overcoming the Fear of SQL with Self-Learning and Feedback**

• Before starting, I assumed using an SQL database would be highly complex. However, after learning SQLite and applying it to this project, I realized that it was not as difficult as I expected.

• I self-learned by searching for keywords on Google and gradually applied the knowledge step by step. Additionally, I shared my progress with my instructor in class, which helped me receive valuable feedback and guidance.

**3. Jupyter Notebook Made Debugging and Learning More Effective**

• This project was completed using Jupyter Notebook, which allowed me to run code in segments and quickly identify and correct errors.

• The ability to execute small parts of the code at a time made it easier to debug and improve the workflow, reducing unnecessary rework.

• The analysis of renewable energy data also gave me insights into how data-driven decision-making is relevant in business contexts, making this a valuable learning and working experience.

**6.2 Challenges Faced**

**1. Difficulties in Data Processing**

• Initially, I wanted to analyze the correlation between variables by splitting the dataset into 10 groups (one for each country) and performing correlation analysis for each country separately.图表, 树状图

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**Example of Attempting Correlation**

• Additionally, I realized that the Renewable Energy (%) value in the dataset was actually the sum of Solar, Wind, Hydro, Geothermal, Biomass, and Other Renewables.

• However, due to missing values and large data volume, some years contained multiple missing values, making accurate data imputation difficult.

• After consulting my instructor, I learned that more advanced machine learning techniques could be used for imputation, which is beyond my current skill set. In the future, I plan to explore machine learning to improve data accuracy and extract more valuable insights.

**2. Choosing a Suitable Data Cleaning Strategy**

• Since Government Investment had large variations between values, with extreme outliers, I decided to use the median for imputation to reduce the impact of outliers.

• For other variables, I used the mean since their distributions were more stable, and applying mean imputation did not significantly impact the accuracy of the analysis.

**3. Challenges in Data Visualization**

• Generating visualizations was one of the most challenging parts of the project.

• Writing long and complex visualization codes, ensuring that data was correctly processed before plotting, and fine-tuning the aesthetics to make the charts both informative and visually appealing required considerable effort.

• One specific challenge I faced was when plotting multiple line charts for different countries.

• By default, Matplotlib shared the x-axis and y-axis across all subplots, which made it difficult to compare individual country trends accurately.

• After discussing with my instructor, I was advised to assign independent x-axis and y-axis scales for each country to ensure clearer and more meaningful comparisons.

• Implementing this change significantly improved the readability and interpretability of the charts.

• Despite these challenges, I gradually became more proficient with Matplotlib and Seaborn, which helped me create effective and meaningful visual representations of data.

**6.3 Skills Developed**

**1. Mastering Pandas, SQLite, and Matplotlib**

• I became familiar with Pandas for data manipulation, SQLite for database management, and Matplotlib for visualization.

• One key takeaway from this project is that not knowing a skill is not as terrifying as not knowing that the skill exists.

• If I don’t know how to use a tool, I can always search, learn, and seek help. However, if I am unaware of the tool’s capabilities, I wouldn’t even know what to search for.

**2. Understanding File Management and Program Execution**

• This project involved handling multiple file types (.ipynb, .csv, .py), which required proper file path management.

• If these files were not stored in the correct directory structure, the program would fail to locate them during execution.

• Through this experience, I gained a better understanding of how file storage and program execution work in a computing environment.

**3. Organizing Code with Markdown for Readability**

• To make my code more structured and readable, I used Markdown cells in Jupyter Notebook to document my workflow.

• This improved code clarity, making it easier to understand the steps taken and the logic behind each analysis.

• This is a valuable practice for collaborative projects and future research work, as it ensures better documentation and reproducibility.

**4. Reinforcing My Career Direction**

• I plan to pursue a career in business analytics, financial engineering, or financial technology.

• This data analysis experience strengthened my interest in data-driven decision-making and reinforced my commitment to learning more advanced and automated data analysis techniques.

• Moving forward, I will explore machine learning, automation, and predictive analytics to expand my skill set.

**6.4 What Could Be Improved**

**1. Refining Data Processing and Workflow Planning**

• Now that I have acquired fundamental data analysis skills, I would like to revisit this project in the future using more advanced data processing techniques.

• Additionally, I realized that some tasks in the project required redoing previous steps, leading to time loss.

• In future projects, I will focus on better workflow planning to avoid redundant efforts and optimize efficiency.

**2. Maximizing Learning Opportunities and Time Management**

• I found that completing work in stages and making use of classroom time to ask my instructor questions was extremely beneficial.

• Moving forward, I will ensure that I stay on track with deadlines and actively seek instructor feedback whenever possible.

• I will also set clear milestones for different phases of a project, allowing for better time management and iterative improvements.

**3. Identifying Areas for Further Learning and Skill Improvement**

• Through this project, I realized that I need to strengthen my knowledge in machine learning-based data processing techniques to improve data imputation accuracy and extract deeper insights.

• Additionally, I plan to explore more efficient and automated data visualization tools to streamline the process of generating complex visualizations.

**7. Conclusion**

**7.1 Summary of Findings**

**1. Renewable energy adoption has been increasing globally, with significant surges in 2010 and 2020.**

• Most countries have shown a steady increase in renewable energy usage, with two key turning points in 2010 and 2020.

• 2010 saw the beginning of rapid growth, likely due to technological advancements, government incentives, and international climate agreements.

• 2020 marked another acceleration, possibly linked to net-zero commitments, post-pandemic green recovery plans, and stricter climate policies.

**2. Different countries have adopted diverse renewable energy strategies.**

• China and Germany have focused on wind and solar energy, leading to a high share of these sources in their energy mix.

• Brazil and Canada remain hydro-dependent, relying on long-established hydropower infrastructure.

• The UK and South Africa lead in wind energy adoption, emphasizing offshore and land-based wind projects.

• India and Australia have taken a more balanced approach, incorporating a mix of solar, wind, and hydro energy.

**3. Renewable energy expansion has contributed significantly to emission reductions.**

• Countries with strong renewable energy policies (e.g., the UK, China, and Germany) have seen the most substantial emission reductions.

• Correlation analysis confirms a strong relationship between renewable energy adoption and emission reductions, validating clean energy policies as an effective strategy for reducing carbon emissions.

• Countries with weaker correlations (e.g., the USA, Canada, and South Africa) may rely on other decarbonization strategies, such as industrial transitions and energy efficiency measures.

**4. Government investment alone does not guarantee higher renewable energy adoption.**

• Despite significant investments, some countries (e.g., Germany, Australia, China) show weak or negative correlations between government spending and renewable energy adoption.

• Effective policy frameworks, infrastructure readiness, and market incentives play a more decisive role than financial investments alone.

**7.2 Policy Recommendation**

Based on the findings, the following policy recommendations are proposed to enhance the effectiveness of renewable energy adoption and emission reduction strategies:

**1. Strengthen policy consistency and long-term commitment.**

• Countries with stable policies have achieved more sustained renewable energy growth.

• Governments should establish long-term renewable energy targets and regulatory frameworks to encourage private investment and infrastructure development.

**2. Enhance energy market structures to support renewable energy expansion.**

• Market-based mechanisms such as carbon pricing, feed-in tariffs, and renewable energy credits can incentivize businesses and individuals to adopt clean energy solutions.

• Governments should ensure grid modernization to accommodate higher renewable energy penetration and improve energy storage capacity.

**3. Improve investment efficiency by focusing on infrastructure and technology deployment.**

• Instead of just increasing financial investment, funding should be directed toward research and development (R&D), infrastructure expansion, and smart grid integration.

• Investments should prioritize emerging technologies such as energy storage, hydrogen energy, and smart energy grids.

**4. Encourage regional cooperation and knowledge sharing.**

• International collaborations can facilitate technology transfer and financial support to developing countries to accelerate renewable energy adoption.

• Regional power grid integration can enhance energy security and optimize renewable energy distribution across countries.

**5. Support data-driven decision-making and further research into advanced energy analytics.**

• Governments and organizations should invest in data science and machine learning applications for renewable energy forecasting and policy impact assessments.

• Open-access energy data platforms can enable better monitoring, planning, and predictive modeling for sustainable energy development.

**7.3 Future Work**

This project provided valuable insights into renewable energy adoption and emission trends, but further research is needed to explore additional aspects of sustainable energy transitions.

**1. Exploring machine learning for predictive analytics in energy transition modeling.**

• Applying machine learning techniques could help forecast renewable energy adoption rates and emission reduction impacts under different policy scenarios.

• Advanced models could be used to predict optimal investment strategies and grid management improvements.

**2. Analyzing sector-specific energy transition impacts.**

• This project focused on national-level renewable energy adoption, but future research could explore sector-specific transitions, such as:

• The role of renewable energy in industrial decarbonization.

• The impact of clean energy adoption in the transportation sector.

• Energy policy effectiveness in residential and commercial sectors.

**3. Assessing socioeconomic impacts of renewable energy policies.**

• Future work could analyze how renewable energy transitions impact employment, economic growth, and social equity.

• Understanding the economic benefits and social challenges associated with clean energy transitions would help design inclusive energy policies.

**4. Comparing global policy frameworks for renewable energy expansion.**

• A comparative study of different policy approaches (e.g., feed-in tariffs, renewable portfolio standards, carbon pricing) could provide deeper insights into the most effective regulatory models.

• Evaluating how policy effectiveness varies across regions could help tailor country-specific energy transition strategies.