Global Energy Trends: A Comprehensive Analysis of Key Regions and Generation Modes using Power BI

1. INTRODUCTION

1.1 Project Overview

Energy plays a vital role in various aspects of modern life, and its importance is expected to increase further as electric vehicles and heat pumps become more prevalent for transportation and heating. Although power generation currently accounts for a significant portion of global CO2 emissions, it is also leading the way in transitioning to net-zero emissions by rapidly adopting renewable energy sources like solar and wind power.

The energy landscape is undergoing a substantial transformation with a strong focus on sustainability and effectiveness. In this context, incorporating renewable energy sources and optimizing energy usage are crucial. Enhancing energy efficiency and integrating renewable generation are key elements in moving towards a more sustainable energy future. Utilizing data analysis techniques within the energy sector holds considerable promise for achieving these goals.

Scenario 1:

Smart Grid Implementation in Urban Areas:

In a bustling urban city, the local government has embarked on a project to upgrade its energy infrastructure to meet the increasing demands sustainably. They have implemented a smart grid system that integrates renewable energy sources like solar and wind power into the existing grid. This system allows for more efficient distribution of electricity, minimizing energy loss during transmission. Moreover, smart meters installed in households provide real-time data on energy consumption, enabling residents to monitor and adjust their usage patterns. As a result, the city experiences reduced reliance on fossil fuels, lower CO2 emissions, and increased resilience to power outages.

Scenario 2:

Industrial Energy Management in Manufacturing Plants: A large manufacturing plant recognizes the importance of optimizing energy usage to enhance its sustainability and cost-effectiveness. Leveraging data analysis techniques, the plant implements an advanced energy management system that monitors energy consumption across various processes in real-time. Through predictive analytics, the system identifies areas of inefficiency and suggests optimization strategies, such as scheduling production during off-peak hours or upgrading equipment to more energy-efficient models. Additionally, the plant integrates renewable energy sources like rooftop solar panels to offset its reliance on grid electricity further. This initiative not only reduces the plant's carbon footprint but also leads to substantial cost savings over time.

Scenario 3:

Rural Electrification Project in Developing Countries

In a remote rural community in a developing country, access to reliable electricity has been a longstanding challenge. To address this issue sustainably, a non-profit organization initiated a rural electrification project focused on utilizing renewable energy sources. They install solar microgrids to power homes, schools, and community centers, providing access to clean and affordable electricity for the first time. Data analytics are employed to optimize the operation of these microgrids, ensuring efficient energy distribution and minimal wastage. As a result, the community experiences significant improvements in living standards, with enhanced educational opportunities, better healthcare facilities, and economic empowerment through small-scale enterprises powered by electricity. This project serves as a model for sustainable development in similar rural areas worldwide, demonstrating the transformative potential of renewable energy and data-driven solutions.

1.2 Objectives

- To analyze historical and recent energy production and consumption across major global regions.
- To compare the usage of various energy generation modes including fossil fuels, renewables, and nuclear.
- To visualize regional differences in energy trends and sustainability indicators.
- To identify patterns and shifts in energy consumption toward cleaner sources.
- To develop a dynamic and user-friendly Power BI dashboard for stakeholders to interact with data.
- To support evidence-based decision-making with meaningful and intuitive visual analytics.

2. Project Initialization and Planning Phase

2.1 Define Problem Statement

The global energy landscape is rapidly evolving due to environmental concerns, technological advancements, and increasing demand for clean energy. However, understanding how different regions contribute to and consume energy across various generation modes remains complex. There is a need for a comprehensive, visual, and data-driven approach to compare regional energy trends, evaluate reliance on different energy sources, and identify areas for sustainable growth.

2.2 Project Proposal (Proposed Solution)

To address the above challenge, this project proposes an analytical dashboard built using **Power BI** to explore, compare, and evaluate global energy trends. The dashboard integrates key metrics such as energy production, consumption, generation types, and emissions across continents. Users can interactively visualize how energy profiles differ by region and how

energy usage is shifting toward renewable sources. This tool aims to assist governments, environmental organizations, and researchers in making informed decisions.

2.3 Initial Project Planning

The project followed a structured plan divided into phases: data collection, cleaning, analysis, visualization, dashboard creation, and reporting. A Gantt chart was prepared for task tracking, and Power BI was chosen for its rich visual capabilities. Datasets were sourced and preprocessed using Excel and Power Query. Milestones were reviewed weekly to ensure timely progress.

3. Data Collection and Preprocessing Phase

3.1. Data Collection Plan and Raw Data Sources Identified

Data collection is the process of gathering and measuring information on variables of interest, in an established, systematic fashion that enables one to answer stated research questions, test hypotheses, evaluate outcomes, and generate insights from the data.

Data was sourced from Kaggle (https://www.kaggle.com/datasets/jamesvandenberg/renewable power-generation).

Data contains all the meta information regarding the columns described in the Excel files.

Description of the Dataset:

There are six data files that collectively form our dataset. The list of files is as follows:

1. Continent Consumption TWH

1. Year
2. World
3. OECD
4. BRICS
5. Europe
6. North America
7. Latin America
8. Asia
9. Pacific
10. Africa
11. Middle East
12. CIS

2. Country Consumption TWH

1. Year
2. China
3. United States
4. Brazil
5. Belgium
6. Czechia
7. France
8. Germany
9. Italy
10. Netherlands
11. Poland
12. Portugal
13. Romania
14. Spain
15. Sweden
16. United Kingdom
17. Norway
18. Turkey
19. Kazakhstan
20. Russia
21. Ukraine
22. Uzbekistan
23. Argentina
24. Canada
25. Chile
26. Colombia
27. Mexico
28. Venezuela

29. Indonesia
30. Japan
31. Malaysia
32. South Korea
33. Taiwan
34. Thailand
35. India
36. Australia
37. New Zealand
38. Algeria
39. Egypt
40. Nigeria
41. South Africa
42. Iran
43. Kuwait
44. Saudi Arabia
45. United Arab Emirates

3. Non-Renewable – Total Power Generation

1. Mode of Generation
2. Contribution (TWH)

4. Renewable – Total Power Generation

1. Mode of Generation
2. Contribution (TWH)

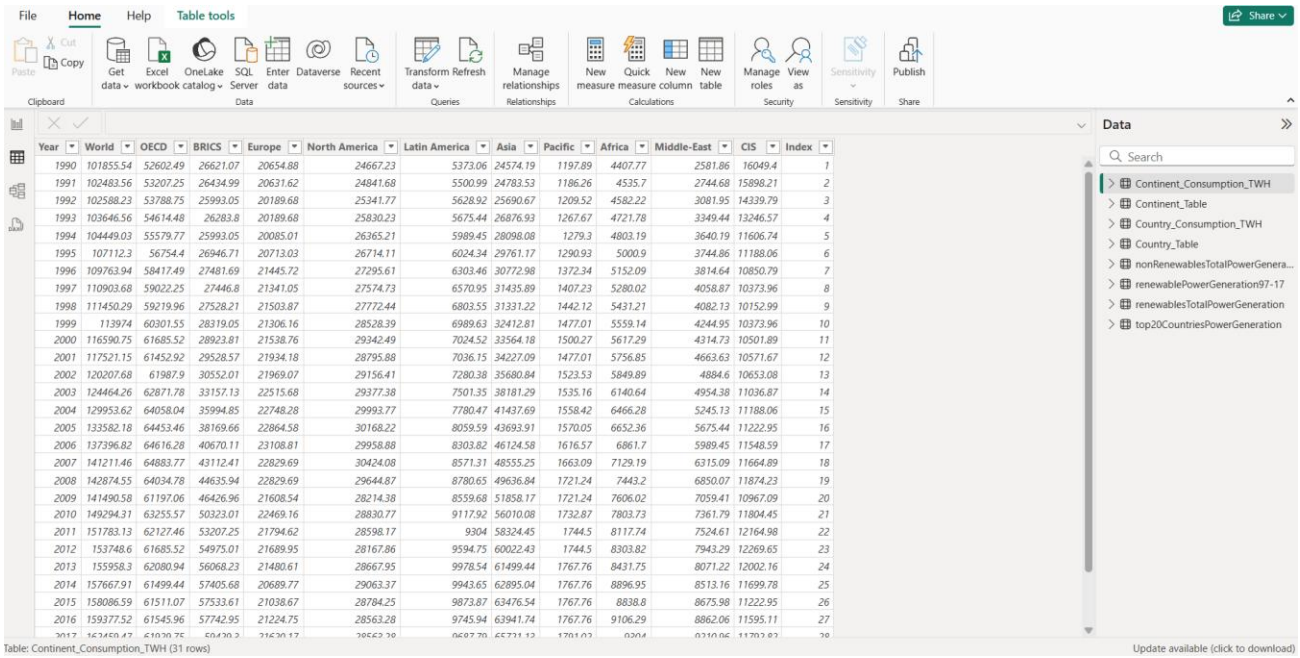
5. Renewable Power Generation 1997-2017

1. Year
2. Solar (TWH)
3. Biofuel (TWH)
4. Hydro (TWH)
5. Geothermal (TWH)

6. Top 20 Countries Power Generation

1. Country
2. Solar PV (TWH)
3. Biofuel (TWH)
4. Hydro (TWH)
5. Geothermal (TWH)
6. Total (TWH)

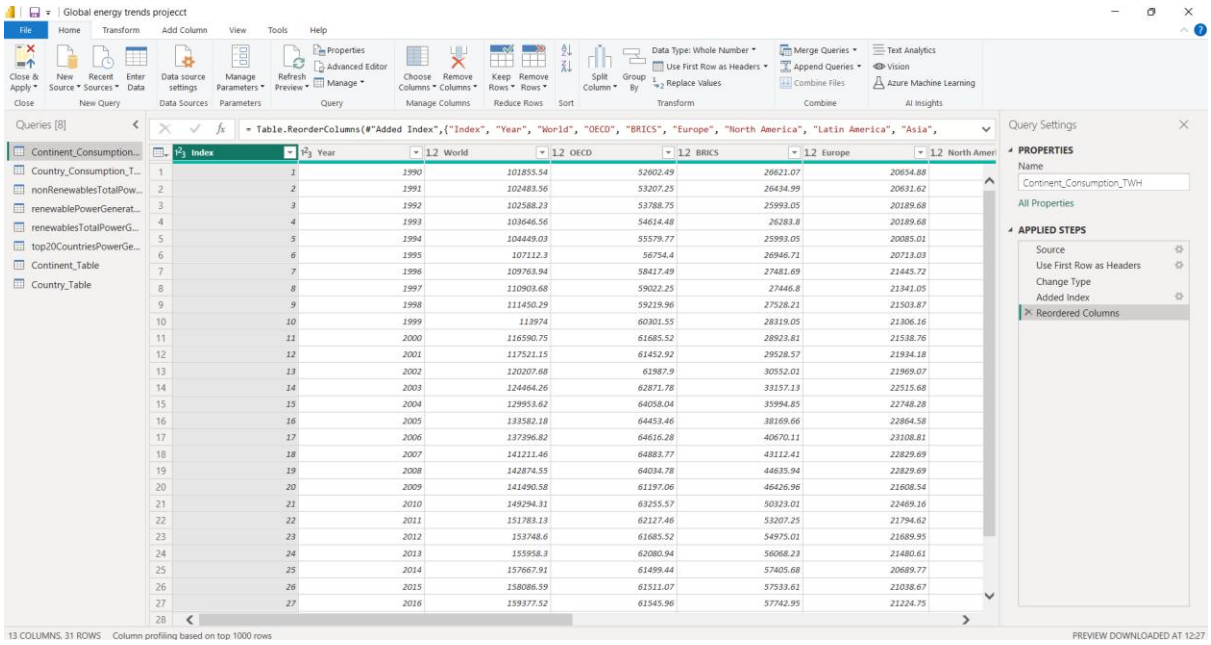
Collected Data:



Year	World	OECD	BRICS	Europe	North America	Latin America	Asia	Pacific	Africa	Middle-East	CIS	Index
1990	101855.54	52602.49	26621.07	20654.88	24667.23	5373.06	24574.19	1197.89	4407.77	2581.86	16049.4	1
1991	102483.56	53207.25	26434.99	20631.62	24841.68	5500.99	24783.53	1186.26	4535.7	2744.68	15898.21	2
1992	102588.23	53788.75	25993.05	20189.68	25341.77	5628.92	25690.67	1209.52	4582.22	3081.95	14339.79	3
1993	103646.56	54614.48	26283.8	20189.68	25830.23	5675.44	26876.93	1267.67	4721.78	3349.44	13246.57	4
1994	104449.03	55579.77	25993.05	20085.01	26365.21	5989.45	28098.08	1279.3	4803.19	3640.19	11606.74	5
1995	107112.3	56754.4	26946.71	20713.03	26714.11	6024.34	29761.17	1290.93	5000.9	3744.86	11188.06	6
1996	109763.94	58417.49	27481.69	21445.72	27295.61	6303.46	30772.98	1372.34	5152.09	3814.64	10850.79	7
1997	110903.68	59022.25	27446.8	21341.05	27574.73	6570.95	31435.89	1407.23	5280.02	4058.87	10373.96	8
1998	111450.29	59219.96	27528.21	21503.87	27772.44	6803.55	31331.22	1442.12	5431.21	4082.13	10152.99	9
1999	113974	60301.55	28319.05	21306.16	28528.39	6989.63	32412.81	1477.01	5559.14	4244.95	10373.96	10
2000	116590.75	61685.52	28923.81	21538.76	29342.49	7024.52	33564.18	1500.27	5617.29	4314.73	10501.89	11
2001	117521.15	61452.92	29528.57	21934.18	28795.88	7036.15	34227.09	1477.01	5756.85	4663.63	10571.67	12
2002	120207.68	61987.9	30552.01	21969.07	29156.41	7280.38	35680.84	1523.53	5849.89	4884.6	10653.08	13
2003	124464.26	62871.78	33157.13	22515.68	29377.38	7501.35	38181.29	1535.16	6140.64	4954.38	11036.87	14
2004	129953.62	64058.04	35994.85	22748.28	29993.77	7780.47	41437.69	1558.42	6466.28	5245.13	11188.06	15
2005	133582.18	64453.46	38169.66	22864.58	30168.22	8059.59	43693.91	1570.05	6652.36	5675.44	11222.95	16
2006	137396.82	64616.28	40670.11	23108.81	29958.88	8303.82	46124.58	1616.57	6861.7	5989.45	11548.59	17
2007	141211.46	64883.77	43112.41	22829.69	30424.08	8571.31	48555.25	1663.09	7129.19	6315.09	11664.89	18
2008	142874.55	64034.78	44635.94	22829.69	29644.87	8780.65	49636.84	1721.24	7443.2	6850.07	11874.23	19
2009	141490.58	61197.06	46426.96	21608.54	28214.38	8559.68	51858.17	1721.24	7606.02	7059.41	10967.09	20
2010	149294.31	63255.57	50323.01	22469.16	28830.77	9117.92	56010.08	1732.87	7803.73	7361.79	11804.45	21
2011	151783.13	62127.46	53207.25	21794.62	28598.17	9304	58324.45	1744.5	8117.74	7524.61	12164.98	22
2012	153748.6	61685.52	54975.01	21689.95	28167.86	9594.75	60022.43	1744.5	8303.82	7943.29	12269.65	23
2013	155958.3	62080.94	56068.23	21480.61	28667.95	9978.54	61499.44	1767.76	8431.75	8071.22	12002.16	24
2014	157667.91	61499.44	57405.68	20689.77	29063.37	9943.65	62895.04	1767.76	8896.95	8513.16	11699.78	25
2015	158086.59	61511.07	57533.61	21038.67	28784.25	9873.87	63476.54	1767.76	8838.8	8675.98	11222.95	26
2016	159377.52	61545.96	57742.95	21224.75	28563.28	9745.94	63941.74	1767.76	9106.29	8862.06	11595.11	27

3.2 Data Quality Report

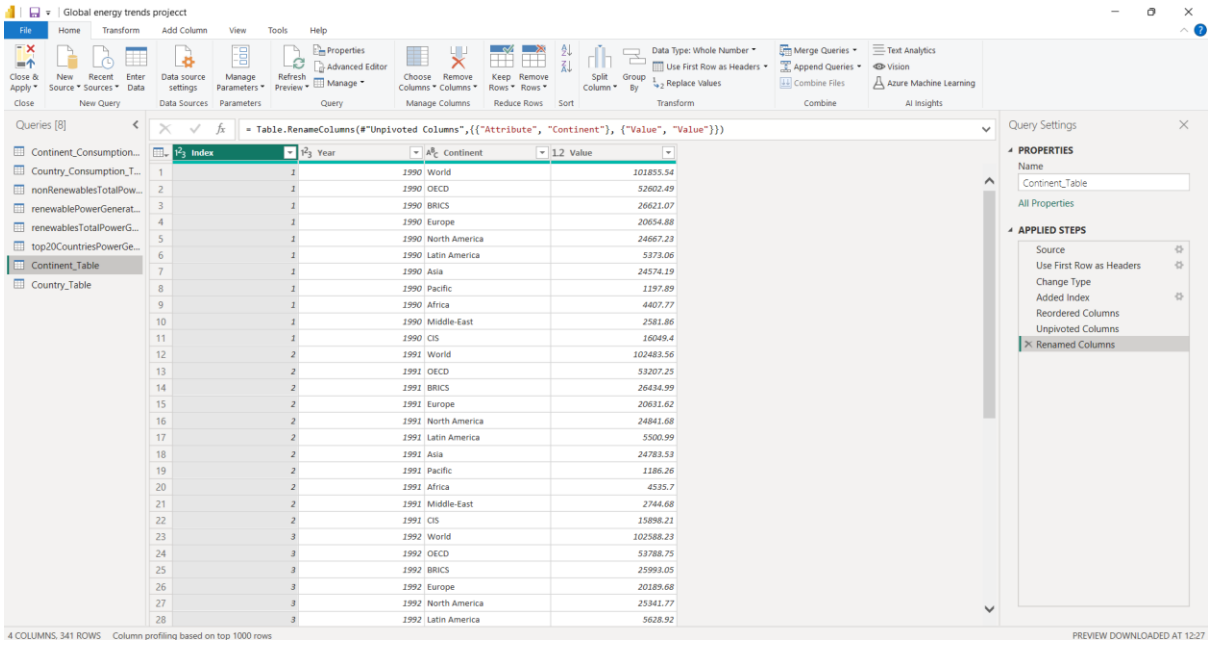
The raw datasets were examined for missing values, duplicates, inconsistent units, and invalid entries. Missing numerical data was either filled using rolling averages or omitted if insignificant. Categorical values were standardized for consistency (e.g., naming of regions and sources). Duplicate rows were removed. Final data quality was deemed suitable for analytical purposes.



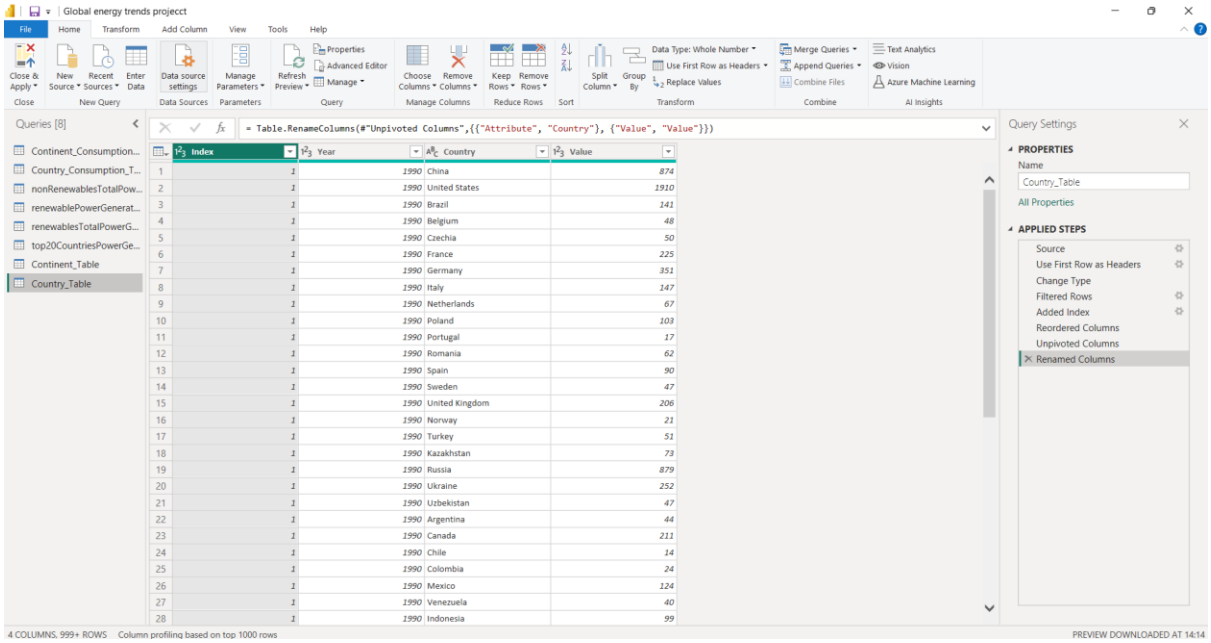
3.3 Data Exploration and Preprocessing

Exploratory data analysis helped in understanding the distribution of energy values, outlier detection, and identifying trends. The data was filtered for relevant years and cleaned using Power Query in Power BI. Columns were renamed and normalized. Measures such as total energy produced, percentage of renewable energy, and average CO_2 emissions were calculated using DAX.

Continent_Table:



Country_Table:



	Index	Year	Country	Value
1	1	1990	China	874
2	1	1990	United States	1910
3	1	1990	Brazil	141
4	1	1990	Belgium	48
5	1	1990	Czechia	50
6	1	1990	France	225
7	1	1990	Germany	351
8	1	1990	Italy	147
9	1	1990	Netherlands	67
10	1	1990	Poland	103
11	1	1990	Portugal	17
12	1	1990	Romania	62
13	1	1990	Spain	90
14	1	1990	Sweden	47
15	1	1990	United Kingdom	206
16	1	1990	Norway	21
17	1	1990	Turkey	51
18	1	1990	Kazakhstan	73
19	1	1990	Russia	879
20	1	1990	Ukraine	252
21	1	1990	Uzbekistan	47
22	1	1990	Argentina	44
23	1	1990	Canada	211
24	1	1990	Chile	14
25	1	1990	Colombia	24
26	1	1990	Mexico	124
27	1	1990	Venezuela	40
28	1	1990	Indonesia	99

4. Data Visualization

4.1. Framing Business Questions

- Which regions are the largest energy producers and consumers?
- What is the trend in renewable vs. non-renewable energy generation over time?
- How does the energy mix vary by continent?
- What is the correlation between energy generation and CO_2 emissions?
- Which regions show the fastest transition toward clean energy?

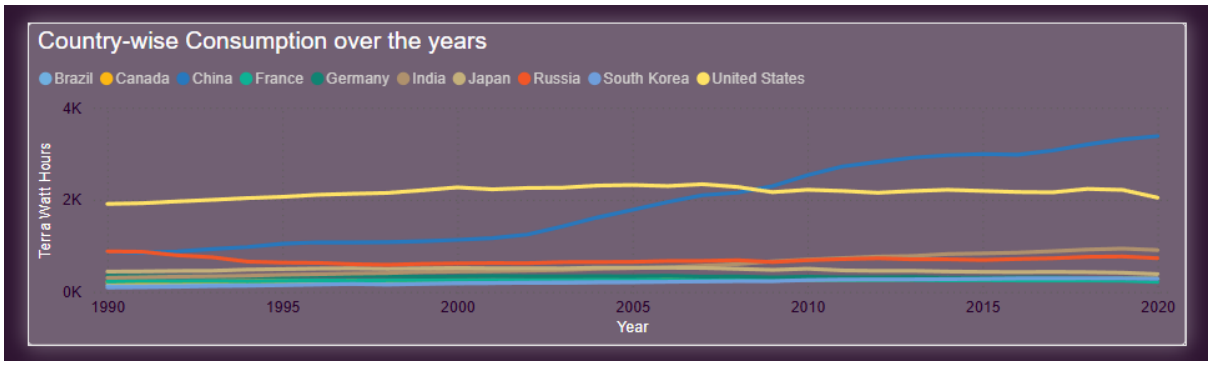
4.2 Developing Visualizations

Data visualization is the process of creating graphical representations of data to help people understand information. The goal of data visualization is to make complex data sets more accessible, intuitive, and easier to interpret. By using visual elements such as charts, graphs, and maps, data visualization can help identify patterns, trends, and outliers quickly in the data.

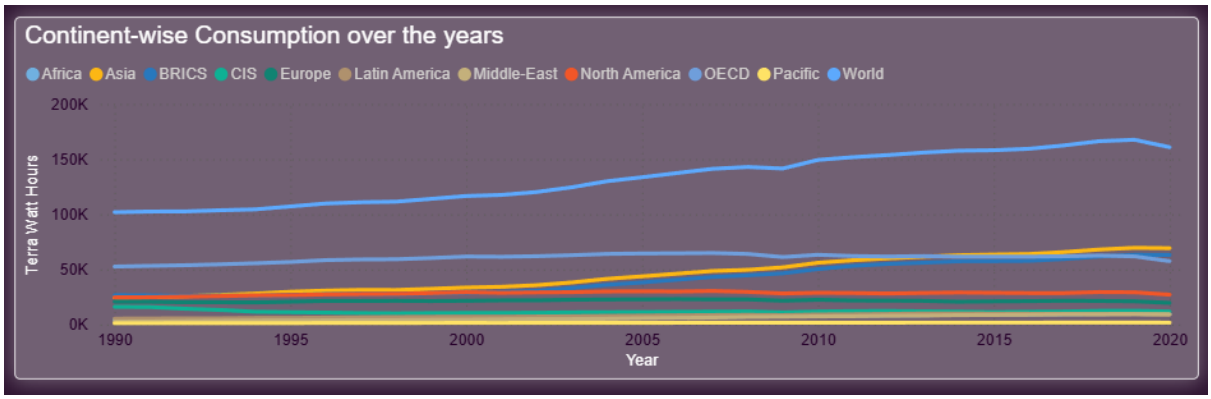
Number of unique visualizations

The number of unique visualizations that can be created with a given dataset. Some common types of visualizations that can be used to analyze include bar charts, line charts, heat maps, scatter plots, pie charts, maps, etc. These visualizations can be used to compare, and track changes over time, show distribution, relationships between variables, breakdown of one category, and much more.

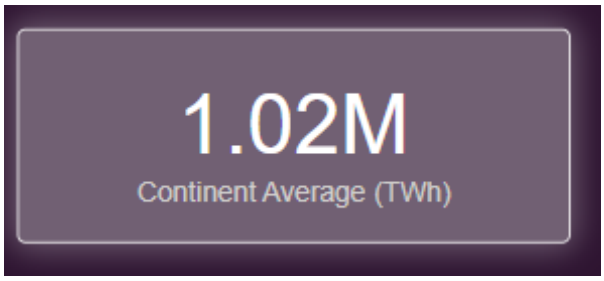
Country-wise consumption



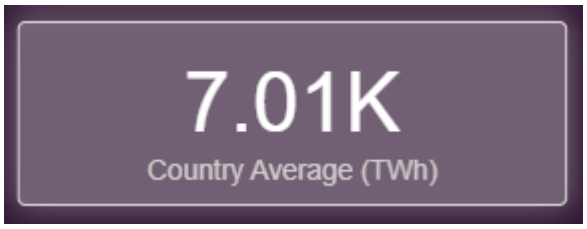
Continent-wise consumption



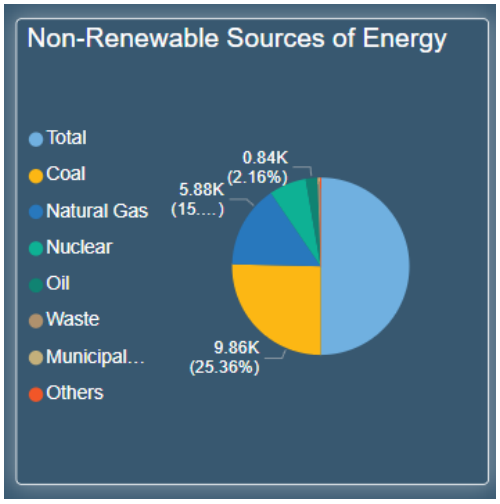
Continent Average



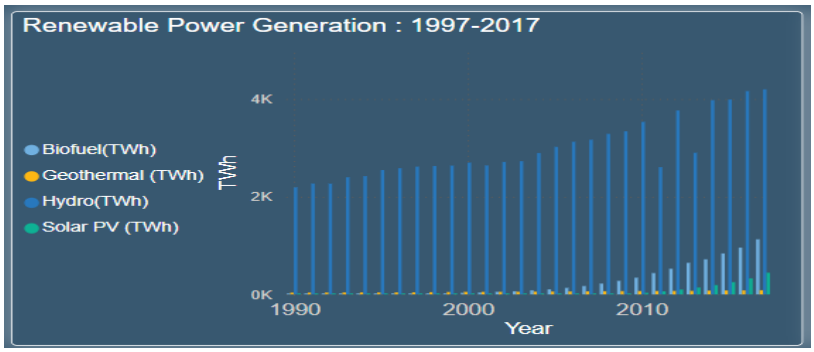
Country Average



Non-Renewable Sources

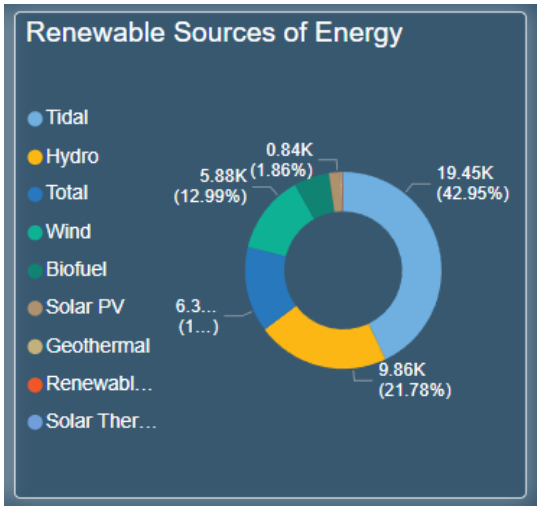


Renewable Power Generation 1997-2017



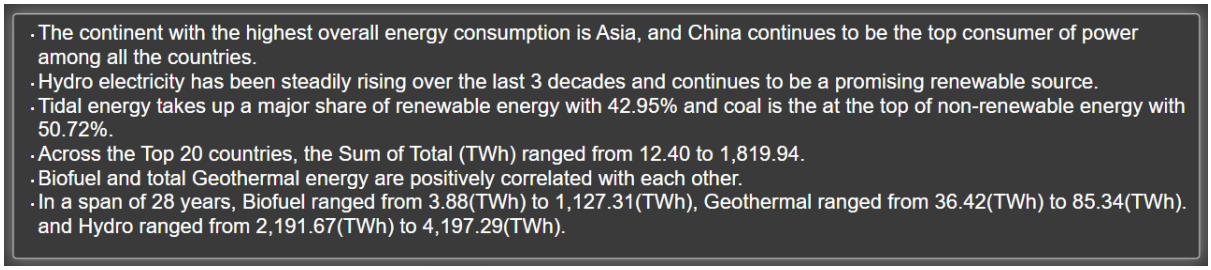
Cards- Sum, Median, Standard Deviation, and Variance of Contribution

Renewable Sources

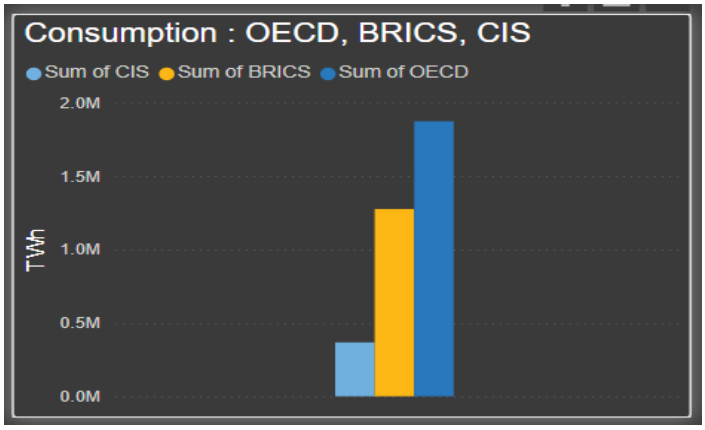


Cards - Geothermal, Bio-fuel, Hydro and Solar PV

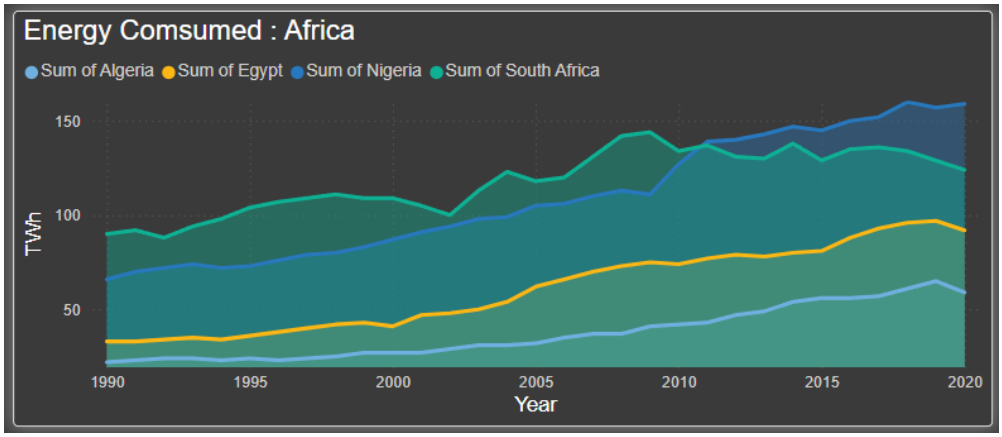
Report Narrative



BRICS, OECD and CIS



Energy Consumption in Africa



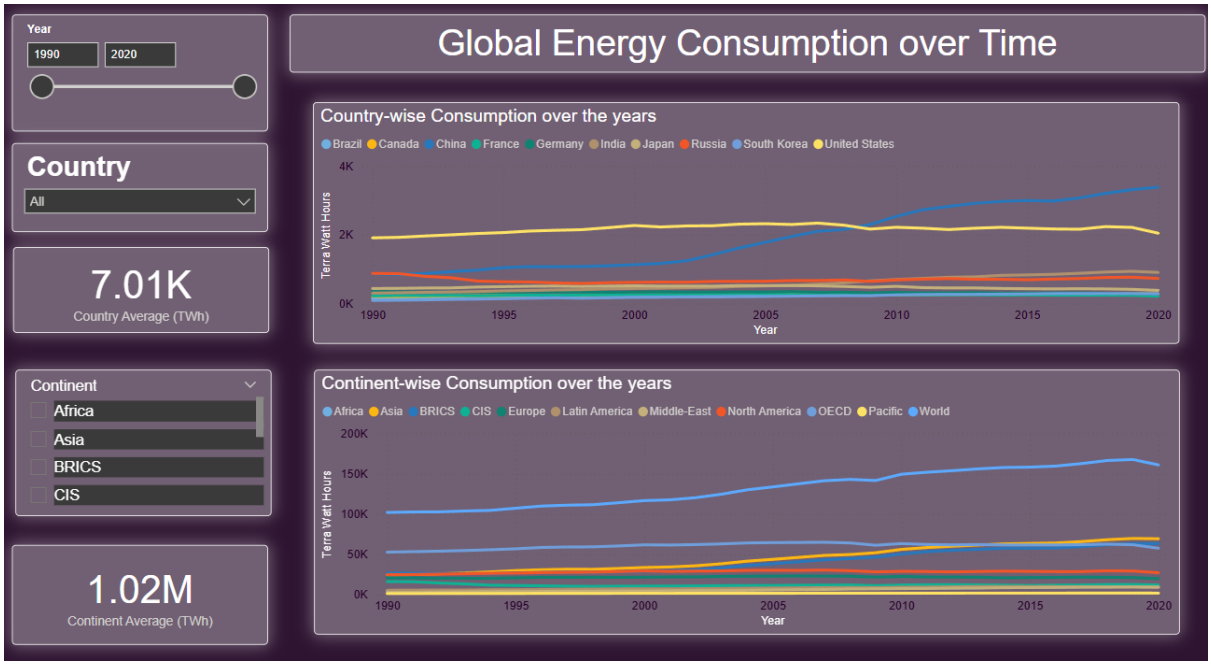
5. Dashboard

5.1. Dashboard Design File

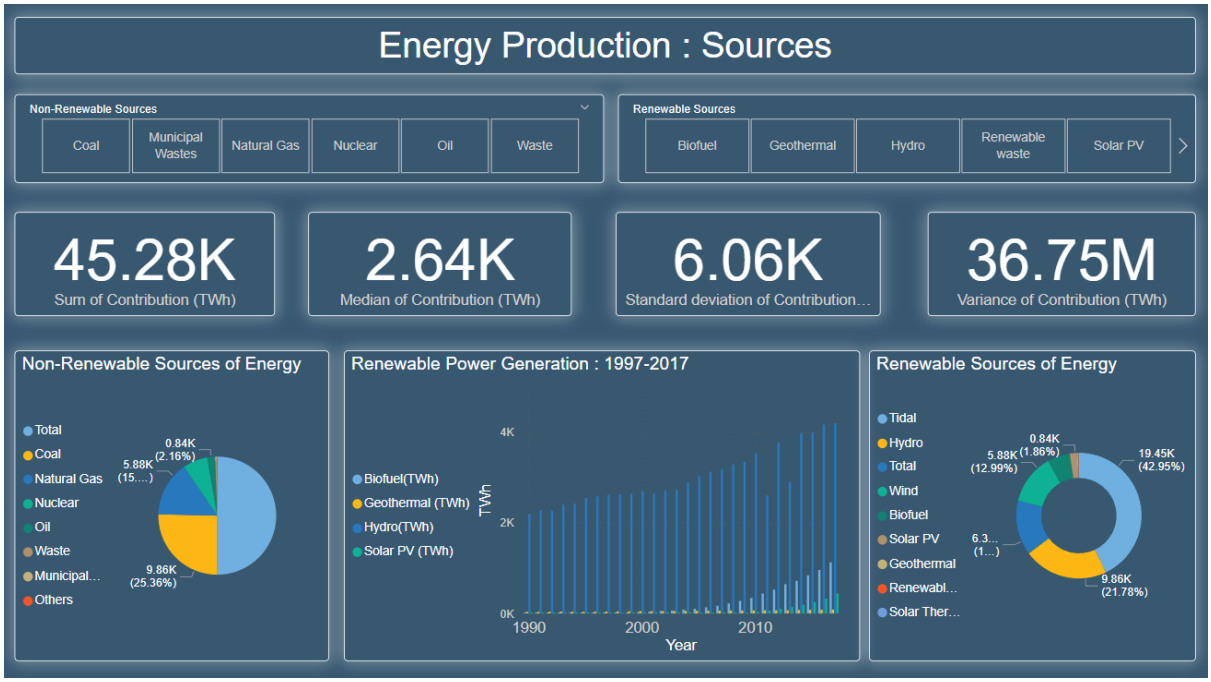
A dashboard is a graphical user interface (GUI) that displays information and data in an organized and easy-to-read format. Dashboards are often used to provide real-time monitoring and analysis of data. They are typically designed for a specific purpose or use case. Dashboards can be used in a variety of settings, such as business, finance, manufacturing, healthcare, and many other industries. They can be used to track key performance indicators (KPIs), monitor performance metrics, and display data in the form of charts, graphs, and tables.

Responsive and Design of Dashboard

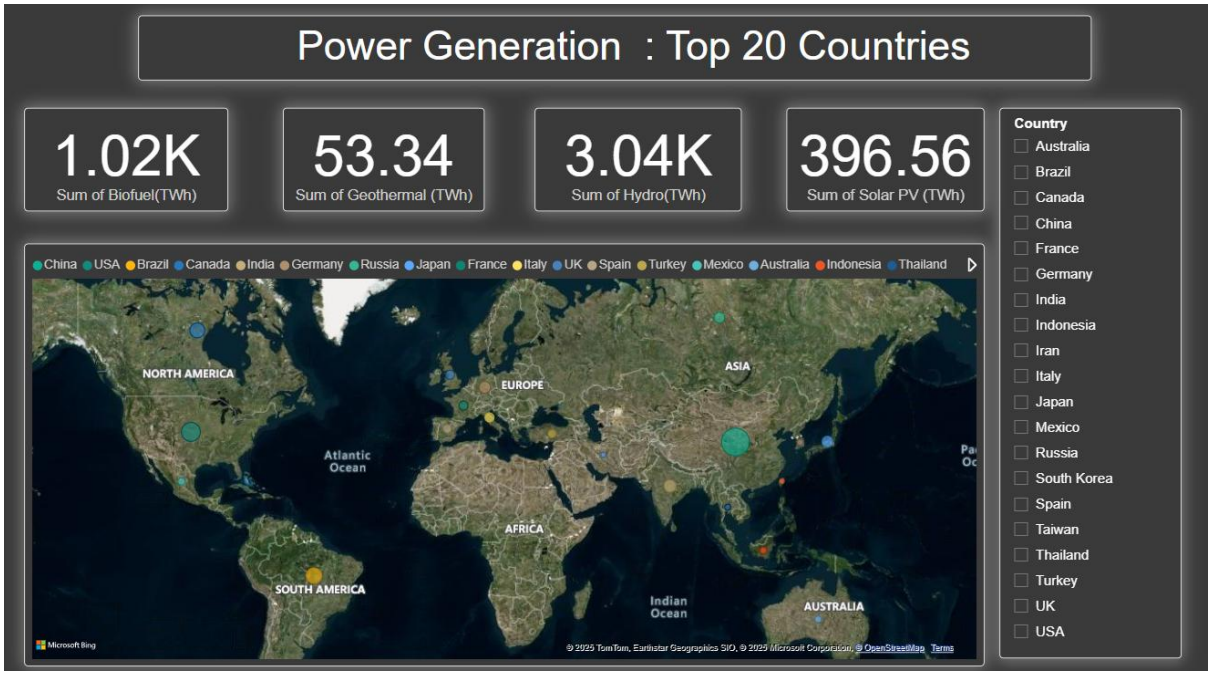
Global Energy Trends Through Time – Slicers for year, country, continent; line charts; and cards for averages.



Energy Sources – Pie and donut charts for source contributions; statistical cards; column charts for renewable trends.



Top 20 Countries Power Generation – Country-wise cards, map visuals, and slicers.



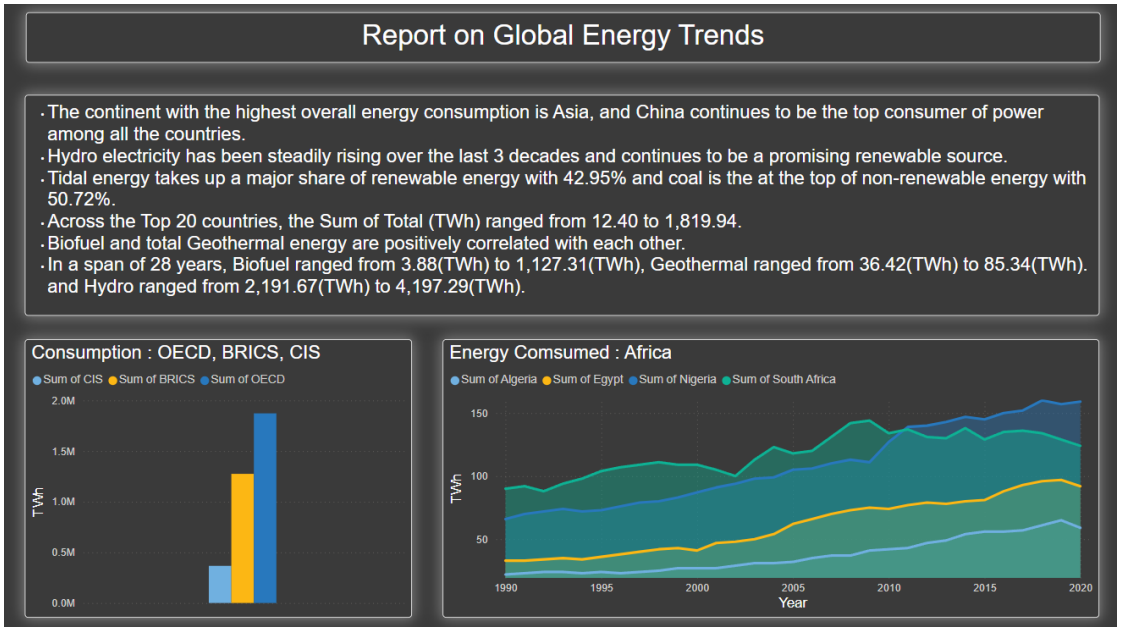
6. Report

6.1. Story Design File

A report is a way of presenting data and analysis in a narrative format, with the goal of making information more engaging and easier to understand. It typically includes a clear introduction that sets the stage and explains the context for the data, a body that presents the data and analysis in a logical and systematic way, and a conclusion that summarizes the key findings and highlights their implications. Data stories can be told using a variety of media, such as reports, presentations, interactive visualizations, and videos.

Design of Report

Narrative Report – Summary of findings with supporting visuals and key observations.

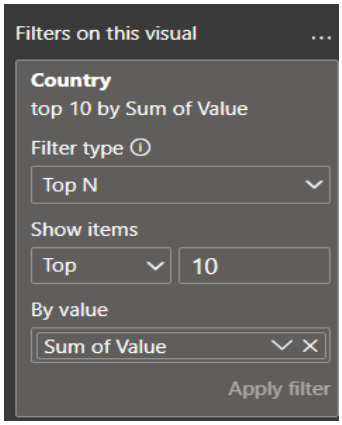


7. Performance Testing

For the aforementioned energy project focusing on incorporating renewable energy sources and optimizing energy usage, performance testing plays a critical role in ensuring the effectiveness and reliability of the implemented systems. Performance testing involves assessing various aspects, including the efficiency of energy generation from renewable sources, the effectiveness of energy distribution through smart grids or microgrids, and the accuracy of data analytics algorithms in identifying optimization opportunities.

7.1 Utilization of Data filters

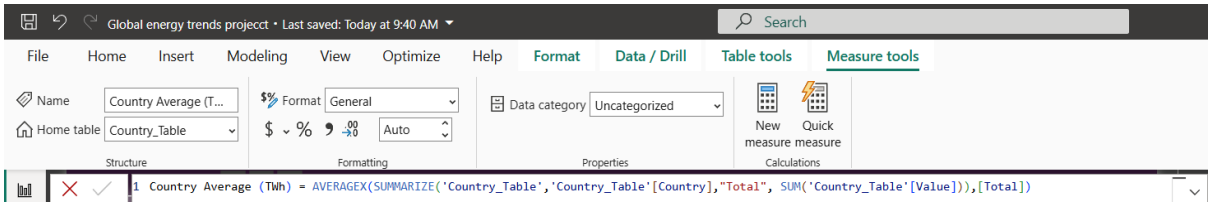
Selections within the data allow users to filter data based on individual fields or dimensions. Users can choose specific values within a field to include or exclude from analysis. Complex filters based on predefined conditions and logic can also be created.



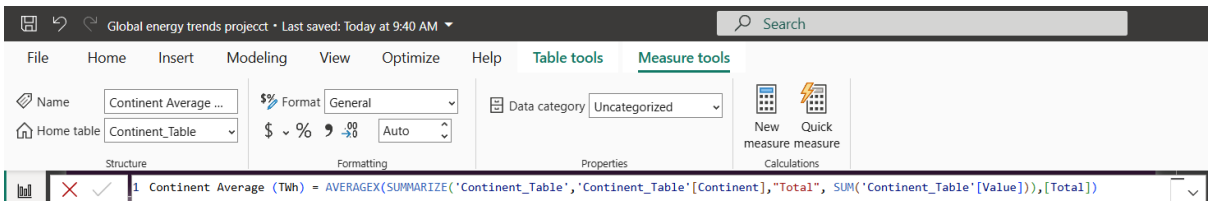
7.2 No of Calculation Field

Power BI allows the creation of reusable filter objects like Measures, and Calculated Columns which can simplify the process of applying consistent filters across multiple visualizations and dashboards.

Country Average (TWh) using AVERAGEX:



Continent Average (TWh) using AVERAGEX:



7.3 No of Visualization

1. Country-wise energy consumption
2. Continent Energy Consumption
3. Continent Average (TWh)
4. Country Average (TWh)
5. Non-renewable sources of Energy
6. Renewable Generation 1997-2017 (TWh)

7. Cards - Sum, Median, Standard Deviation and Variance of Contribution (TWh)
8. Renewable Sources of Energy
9. Cards - Geothermal, Biofuel, Hydro and Solar PV
10. BRICS, OECD, and CIS Comparison
11. Report Narrative
12. Energy Consumption in African countries

8. Conclusion/Observation

This project effectively demonstrates how data analytics and Power BI can be applied to understand global energy consumption trends. By integrating clean data, meaningful transformations, and dynamic dashboards, it delivers insights into the transition to renewable energy.

The findings support strategic planning for energy sustainability and highlight key regional behaviors and generation methods essential for policy and infrastructure development. The visual analysis enables stakeholders to identify not just where energy is produced or consumed, but how different regions are adapting to sustainable practices, thereby aiding in global energy planning and climate action.

9. Future Scope

The project can be expanded to include:

- Forecasting future energy trends using predictive models.
- Integration with real-time energy data APIs.
- Country-wise policy analysis for renewable energy incentives.
- Correlation with GDP and population for deeper socio-economic insights.

10. Appendix

10.1. Source Code (if any)

No Source code used.

10.2. GitHub & Project Demo Link

GitHub Repo: https://github.com/AllagadapaAnjali/Global_Energy_Trends_PowerBi.git

Demo Video: -------