

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

INTRODUCTION :-

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.

SCENARIOS

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 a 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 micro grids 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 micro grids, 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.

Technical Architecture:



PROJECT FLOW

1. Data Collection

- Collect the dataset
- Connect Data to Tableau

2. Data Preparation

- Prepare the Data for Visualization

3. Data Visualizations

- Number of Unique Visualizations

4. Dashboard

- Response and Design of Dashboard

5. Report

- Report Creation

6. Performance Testing

- Utilization of Data Filters
- Number of Calculated Columns/Measures
- Number of Visualizations/Graphs

7. Project Demonstration & Documentation

- Record explanation Video for project end-to-end solution
- Project Documentation - Step by step project development procedure

- Investigate the contribution of various types of sources to the total energy produced.

MILESTONE 1: DATA COLLECTION & EXTRACTION FROM DATABASE

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

Columns in the dataset:

- Year
- China
- United States
- Brazil
- Belgium
- Czechia
- France
- Germany

- Italy
- Netherlands
- Poland
- Portugal
- Romania
- Spain
- Sweden
- United Kingdom
- Norway
- Turkey
- Kazakhstan
- Russia
- Ukraine
- Uzbekistan
- Argentina
- Canada
- Chile
- Colombia
- Mexico
- Venezuela
- Indonesia
- Japan
- Malaysia
- South Korea
- Taiwan
- Thailand
- India
- Australia
- New Zealand
- Algeria
- Egypt
- Nigeria
- South Africa
- Iran
- Kuwait
- Saudi Arabia
- United Arab Emirates

3. Non-Renewable – Total Power Generation

Columns in the dataset:

- Mode of Generation
- Contribution (TWH)

4. Renewable – Total Power Generation

Columns in the dataset:

- Mode of Generation
- Contribution (TWH)
-

5. Renewable Power Generation 1997-2017

Columns in the dataset:

- Year
- Solar (TWH)
- Bio-fuel (TWH)
- Hydro (TWH)
- Geothermal (TWH)

6. Top 20 Countries Power Generation

Columns in the dataset:

- Country
- Solar PV (TWH)
- Bio-fuel (TWH)
- Hydro (TWH)
- Geothermal (TWH)
- Total (TWH)

MILESTONE 2: DATA PREPARATION

Preparing the data for visualization involves cleaning the data to remove irrelevant or missing data, transforming the data into a format that can be easily visualized, exploring the data to identify patterns and trends, filtering the data to focus on specific subsets of data, preparing the data for visualization software, and ensuring that the data is accurate and complete.

Null values were removed, data types verified, and an index column was added to support relationship creation. Geothermal values were rounded to two decimal places in the Top 20

Countries dataset.

DATA TRANSFORMATION

Duplicated and renamed datasets as Country_Table and Continent_Table, unpivoted country/continent columns to create a unified structure with "attribute" and "value" fields renamed as "Country/Continent" and "Value" respectively. These were connected through index columns.

Country_Table:

Index	Year	Country	Value
1	1990	China	874
2	1990	United States	2910
3	1990	Brazil	141
4	1990	Belgium	48
5	1990	Czechia	50
6	1990	France	225
7	1990	Germany	351
8	1990	Italy	147
9	1990	Netherlands	67
10	1990	Poland	103
11	1990	Portugal	17
12	1990	Romania	62
13	1990	Spain	90
14	1990	Sweden	47
15	1990	United Kingdom	206
16	1990	Norway	21
17	1990	Turkey	51
18	1990	Kazakhstan	73
19	1990	Russia	879
20	1990	Ukraine	252
21	1990	Uzbekistan	47
22	1990	Argentina	44
23	1990	Canada	211
24	1990	Chile	14
25	1990	Colombia	24
26	1990	Mexico	124
27	1990	Venezuela	40

Continent_Table:

Index	Year	Continent	Value
1	1990	World	101855.54
2	1990	OECD	52602.49
3	1990	BRICS	26021.07
4	1990	Europe	20654.88
5	1990	North America	24667.23
6	1990	Latin America	5373.06
7	1990	Asia	24574.19
8	1990	Pacific	1197.89
9	1990	Africa	4407.77
10	1990	Middle-East	2581.86
11	1990	CIS	16049.4
12	1991	World	102483.56
13	1991	OECD	53207.25
14	1991	BRICS	26434.99
15	1991	Europe	20631.62
16	1991	North America	24841.68
17	1991	Latin America	5500.99
18	1991	Asia	24783.53
19	1991	Pacific	1186.26
20	1991	Africa	4535.7
21	1991	Middle-East	2744.68
22	1991	CIS	15898.21
23	1992	World	102588.23
24	1992	OECD	53788.75
25	1992	BRICS	25993.05
26	1992	Europe	20189.68
27	1992	North America	25341.77

MILESTONE 3: DATA VISUALIZATION

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 people identify patterns, trends, and outliers quickly in the data.

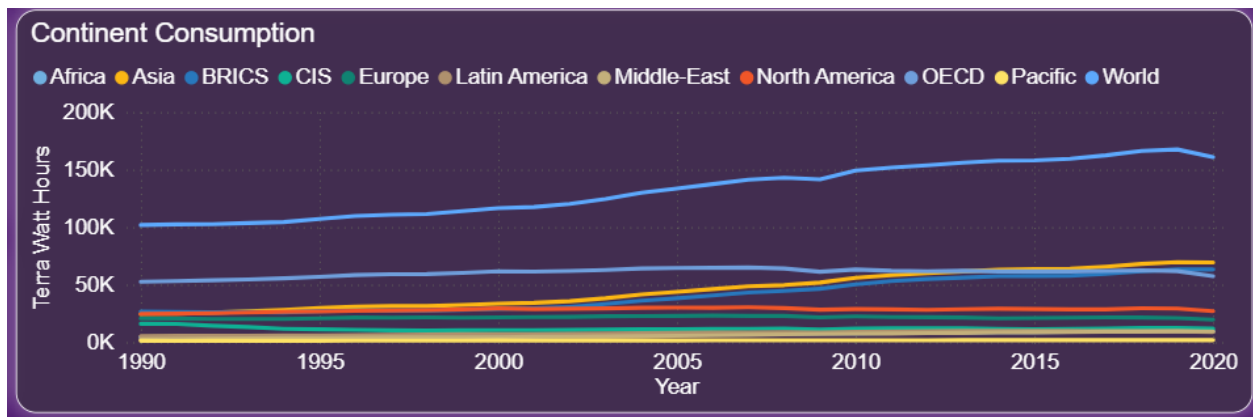
Number of unique visualizations

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 Consumption



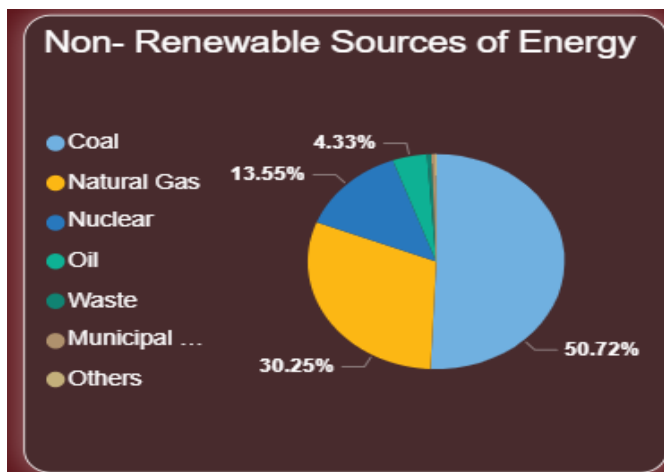
Continent Average



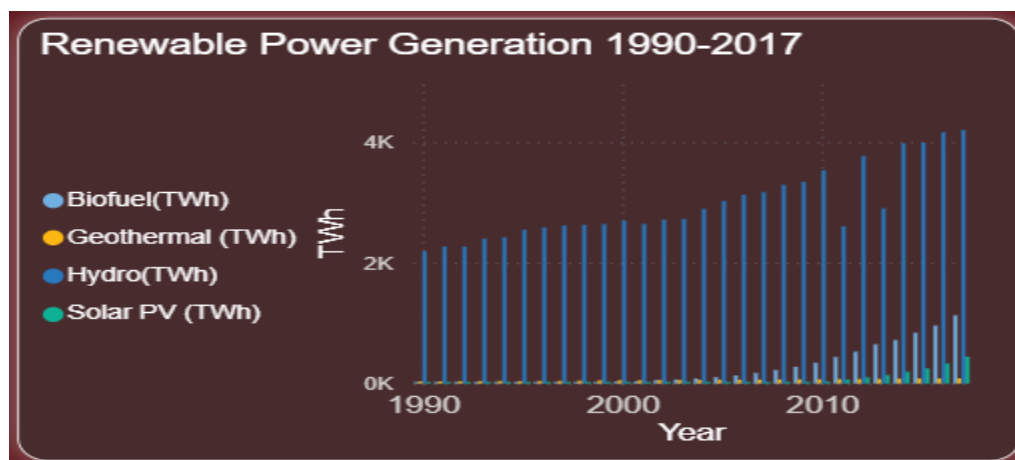
Country Average



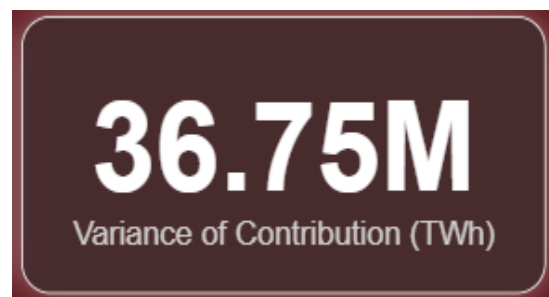
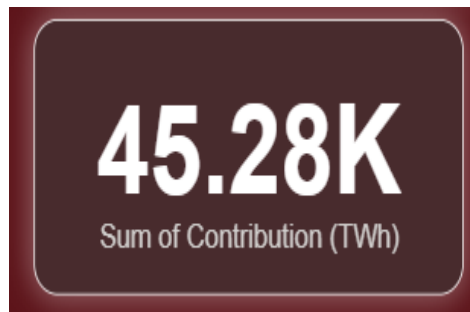
Non-Renewable Sources



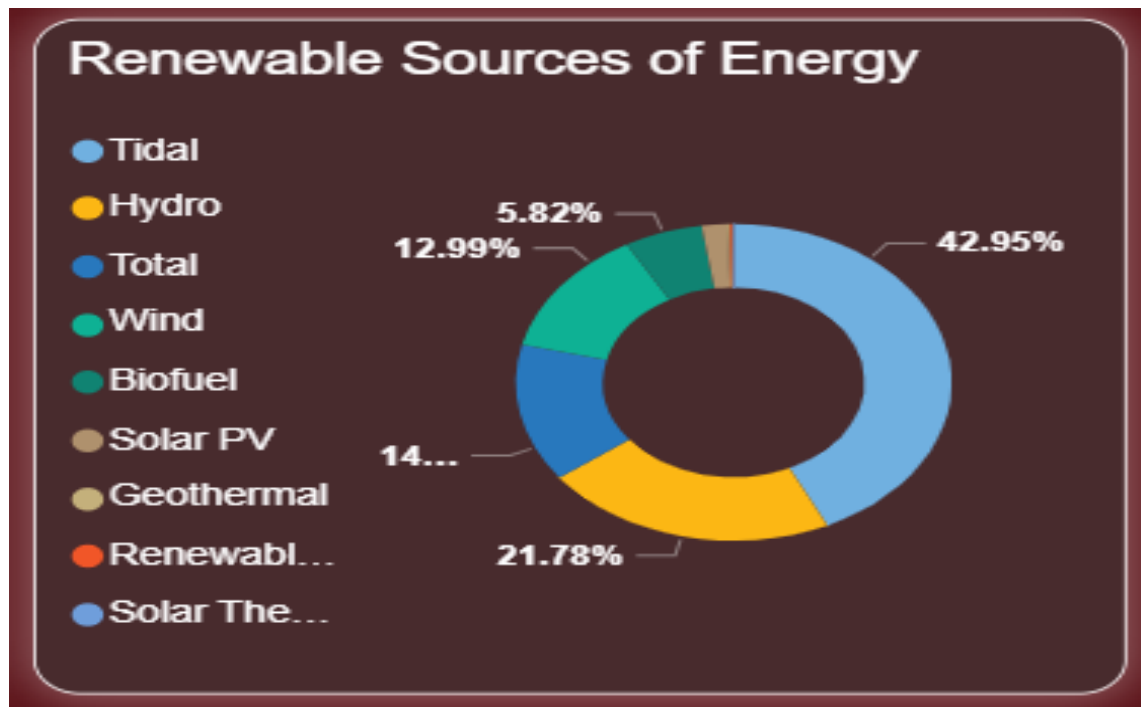
Renewable Generation 1997-2017



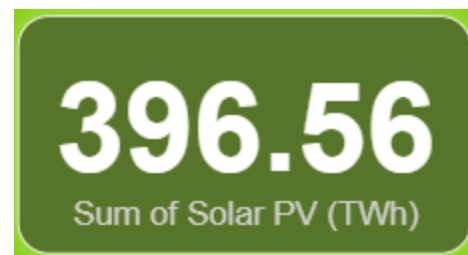
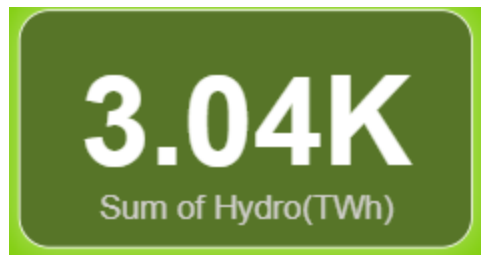
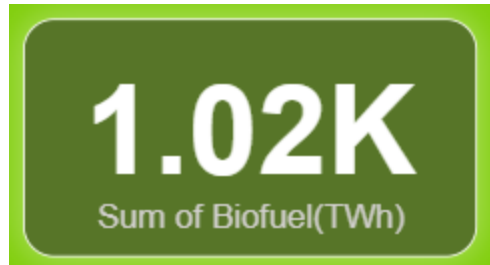
Cards- Sum, Median, Standard Deviation, and Variance of Contribution



Renewable Sources



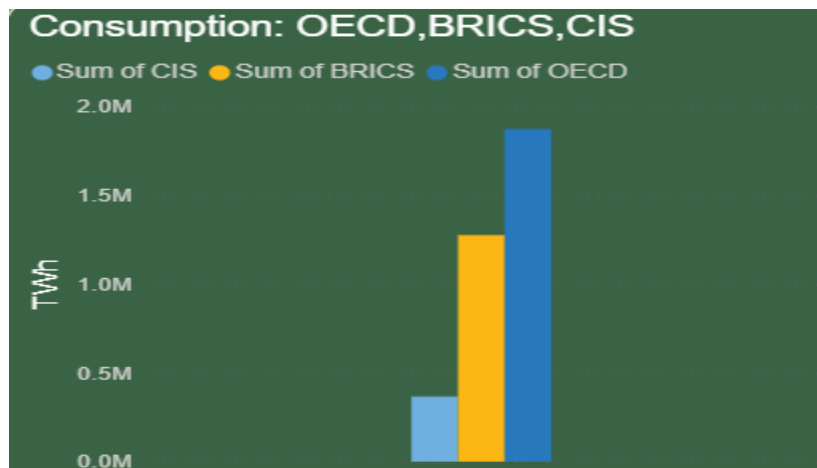
Cards - Geothermal, Bio-fuel, Hydro and Solar PV



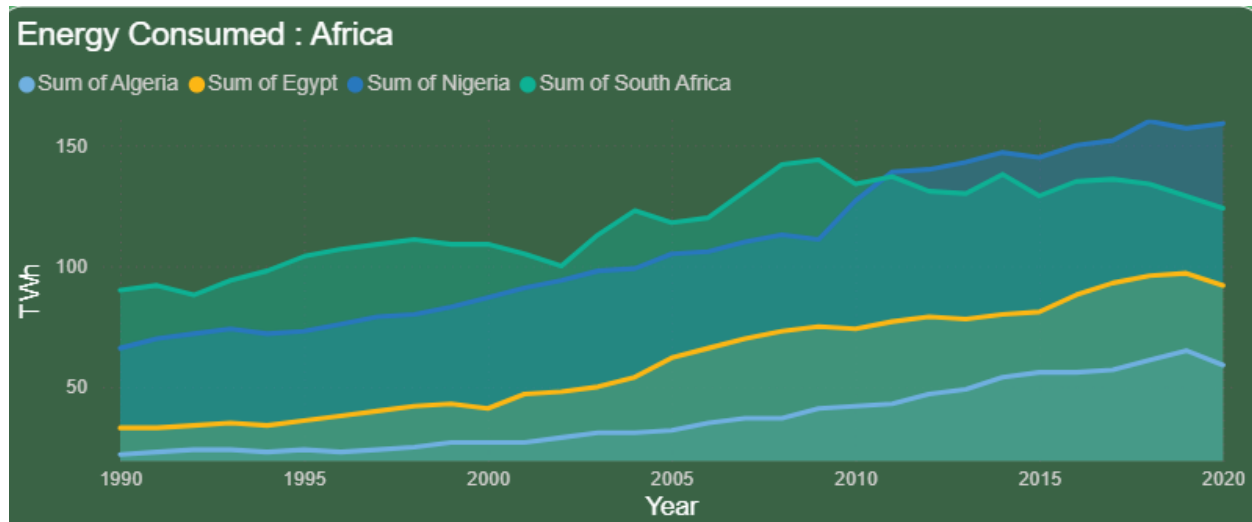
Report Narrative

- . The Continent with the highest overall energy consumption is Asia, and China continues to be the top consumer of power among all the countries.
- . Hydro electricity has been steadily rising over the last 3 decades and continues to be a promising renewable source.
- . Tidal energy takes up a major share of renewable energy with 42.95% and coal is at the top of non-renewable energy with 50.72%.
- . Across the Top 20 countries, the sum of Total(TWh) ranged from 12.40 to 1,819.94.
- . Biofuel and total Geothermal energy are positively correlated with each other.
- . In a span of 28 years, Biofuel ranged from 3.88(TWh) to 1,127.31(TWh), Geothermal ranged from 36.42(TWh) to

BRICS, OECD and CIS



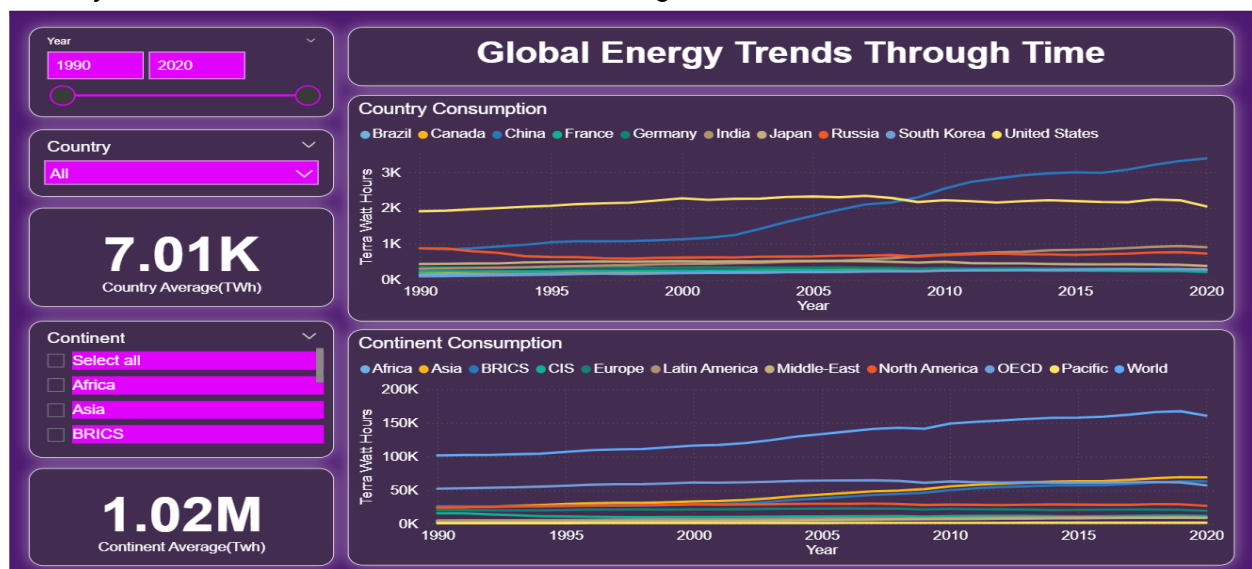
Energy Consumption in Africa



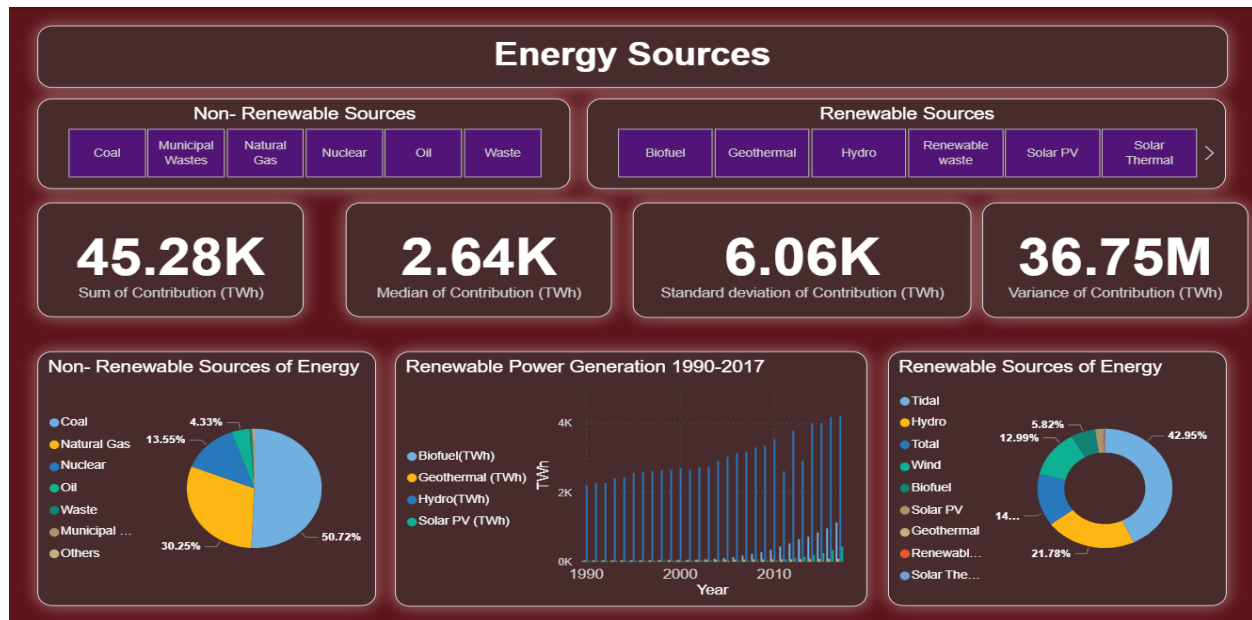
MILESTONE 4: DASHBOARD

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.

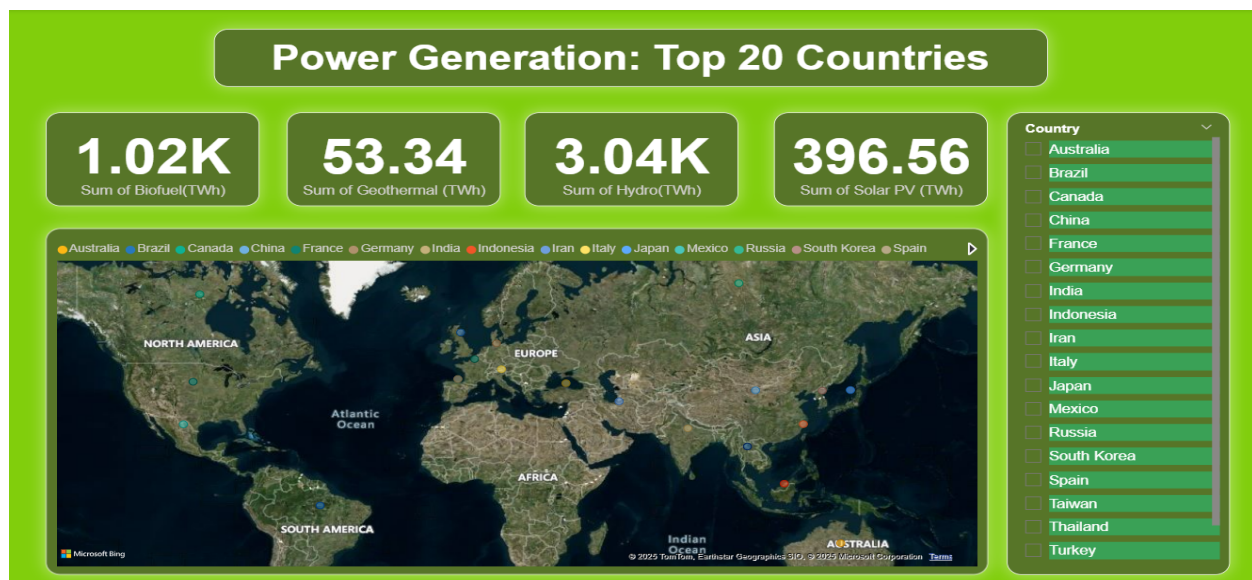


Energy Sources – Pie and donut charts for source contributions; statistical cards; column charts for renewable trends.



Top 20 Countries Power Generation –

Country-wise cards, map visuals, and slicers.

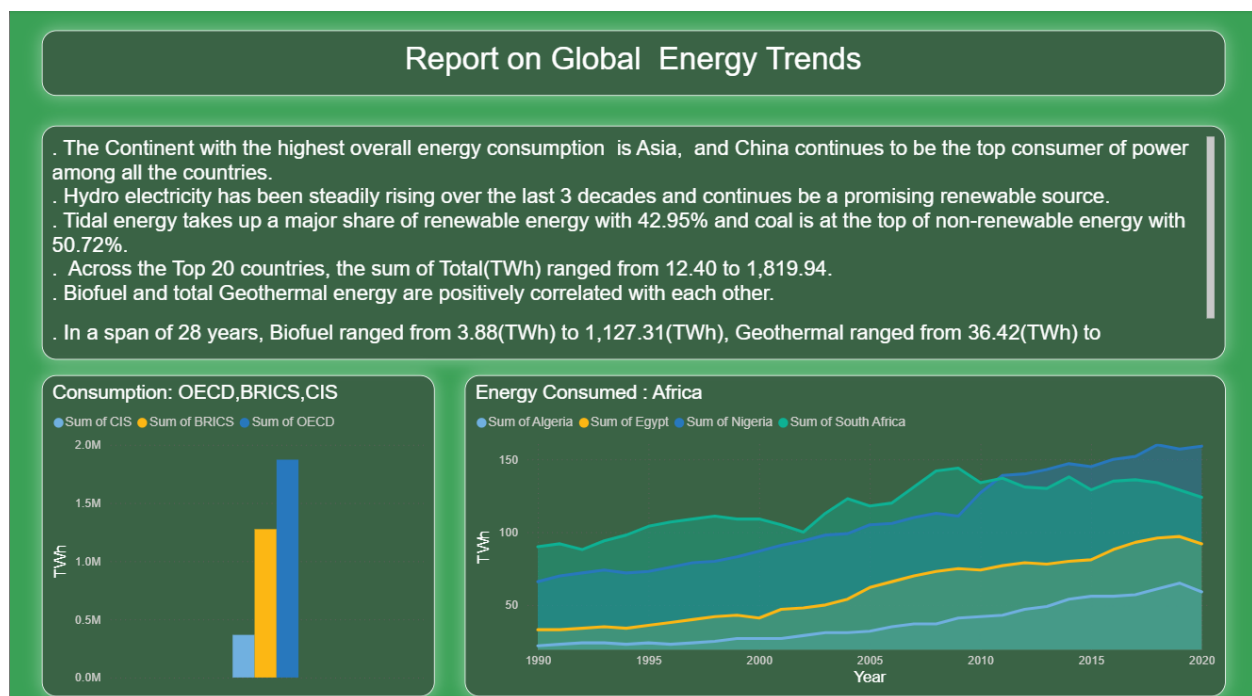


MILESTONE 5: REPORT

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.

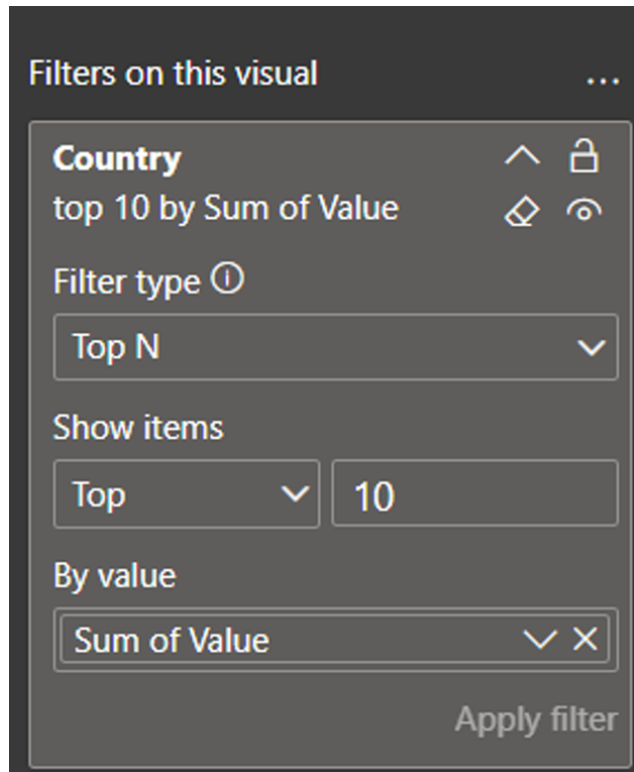


MILESTONE 6: PERFORMANCE TESTING

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 micro-grids, and the accuracy of data analytics algorithms in identifying optimization opportunities.

Application of Data Filters

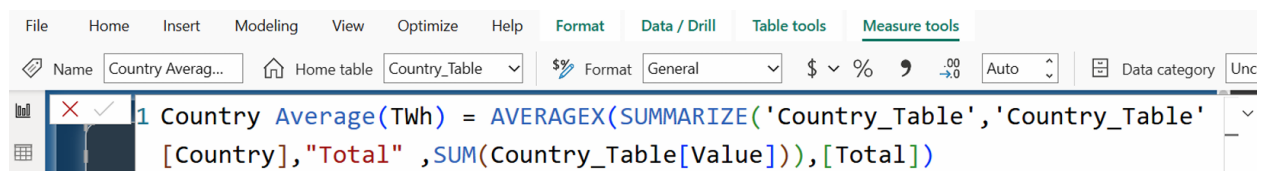
Selections within the data allow users to filter data based on individual fields or dimensions. Users can choose specific values within a field to include or exclude from analysis. Complex filters based on predefined conditions and logic can also be created.



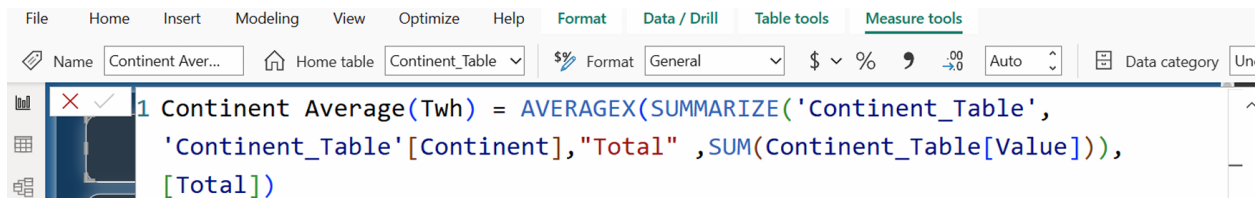
Use of Measures/Calculated Columns

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:



Number of Graphs/ Visualizations

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, Bio-fuel, Hydro and Solar PV
10. BRICS, OECD, and CIS Comparison
11. Report Narrative
12. Energy Consumption in African countries

Conclusion:

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.

MILESTONE 7: PROJECT DEMONSTRATION & DOCUMENTATION

Video demonstration:

<https://drive.google.com/file/d/12qQm3HiVIMGRG91TbzqilcQ4ynjOVkRn/view?usp=sharing>