

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/jamesvandenbergh/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:

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

Columns in the dataset:

1. Mode of Generation
2. Contribution (TWH)

4. Renewable – Total Power Generation

Columns in the dataset:

1. Mode of Generation
2. Contribution (TWH)

5. Renewable Power Generation 1997-2017

Columns in the dataset:

1. Year
2. Solar (TWH)
3. Bio-fuel (TWH)
4. Hydro (TWH)
5. Geothermal (TWH)

6. Top 20 Countries Power Generation

Columns in the dataset:

1. Country
2. Solar PV (TWH)
3. Bio-fuel (TWH)
4. Hydro (TWH)
5. Geothermal (TWH)
6. 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:

Global Energy Trends

File

Home

Transform

Add Column

View

Tools

Help

Close & Apply

New Source

Recent Sources

Enter Data

Data source settings

Manage Parameters

Refresh Preview

Properties

Advanced Editor

Manage

Choose Columns

Remove Columns

Keep Rows

Remove Rows

Sort

Split Column

Group By

Data Type: Whole Number

Use First Row as Headers

Replace Values

Merge Queries

Append Queries

Combine Files

Text Analytics

Vision

Azure Machine Learning

Combine

AI Insights

Queries [8]

Continent_Table

Country_Table

nonRenewablesTotalPow...

renewablePowerGenerat...

renewablesTotalPowerG...

top20CountriesPowerGe...

Continent_Consumption...

Country_Consumption_T...

Table.RenameColumns(#Unpivoted Columns,{"Attribute", "Country"}, {"Value", "Value"})

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27

Index

Year

Country

Value

1990

China

874

1990

United States

1910

1990

Brazil

141

1990

Belgium

48

1990

Czechia

50

1990

France

225

1990

Germany

351

1990

Italy

147

1990

Netherlands

67

1990

Poland

103

1990

Portugal

17

1990

Romania

62

1990

Spain

90

1990

Sweden

47

1990

United Kingdom

206

1990

Norway

21

1990

Turkey

51

1990

Kazakhstan

73

1990

Russia

879

1990

Ukraine

252

1990

Uzbekistan

47

1990

Argentina

44

1990

Canada

211

1990

Chile

14

1990

Colombia

24

1990

Mexico

124

1990

Venezuela

40

4 COLUMNS, 999+ ROWS

Column profiling based on top 1000 rows

PREVIEW DOWNLOADED AT 11:03

Continent_Table:

Global Energy Trends

File Home Transform Add Column View Tools Help

Close & Apply New Source Recent Enter Data Data source settings Manage Parameters Refresh Advanced Editor Choose Columns Remove Columns Keep Rows Remove Rows Split Column Group By Data Type: Whole Number Use First Row as Headers Use Replace Values Merge Queries Append Queries Combine Files Text Analytics Vision Azure Machine Learning AI Insights

Queries [8]

Continent_Table

Country_Table

nonRenewablesTotalPower...

renewablePowerGenerat...

renewablesTotalPowerGe...

top20CountriesPowerGe...

Continent_Consumption...

Country_Consumption_T...

Table: RenameColumns(#Unpivoted Columns",{"Attribute", "Continent"}, {"Value", "Value"}))

Index	Year	Continent	Value
1	1990	World	101855.54
2	1990	OECD	52602.49
3	1990	BRICS	26621.07
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

4 COLUMNS: 341 ROWS - Column headers based on top 1000 rows

PROVIEW DOWNLOADED AT 11:03

Query Settings

PROPERTIES

Name

Continent_Table

All Properties

APPLIED STEPS

Source

Use First Row as Headers

Change Type

Added Index

Reordered Columns

Unpivoted Columns

Renamed Columns

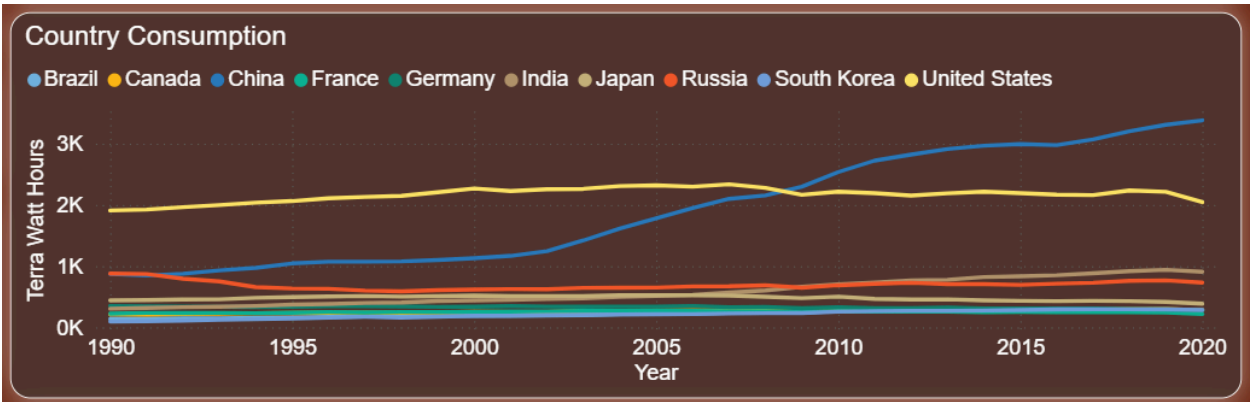
MILESTONE 3: DATA VISUALIZATION

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.

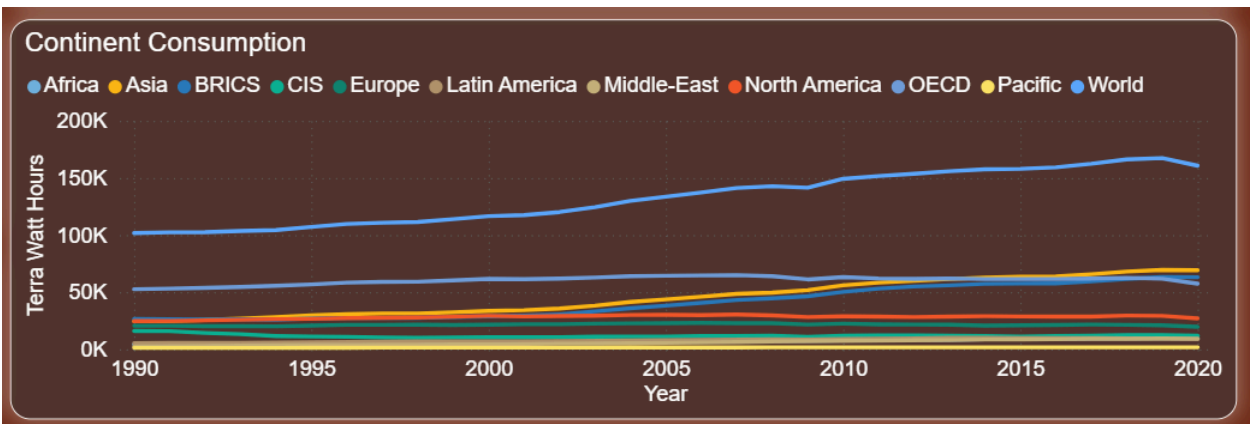
Number of unique visualizations

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.

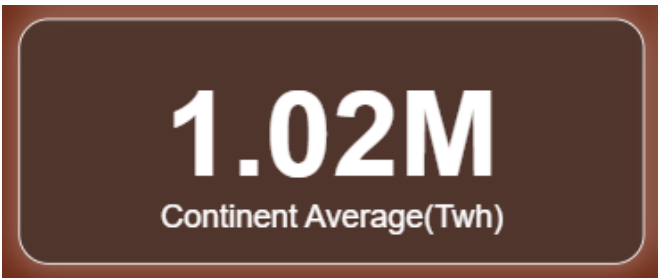
Country wise consumption



Continent Consumption



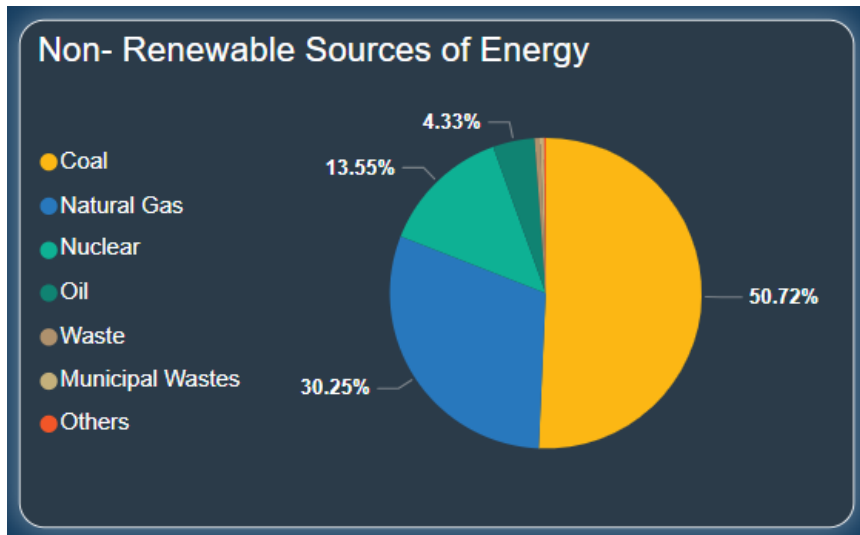
Continent Average



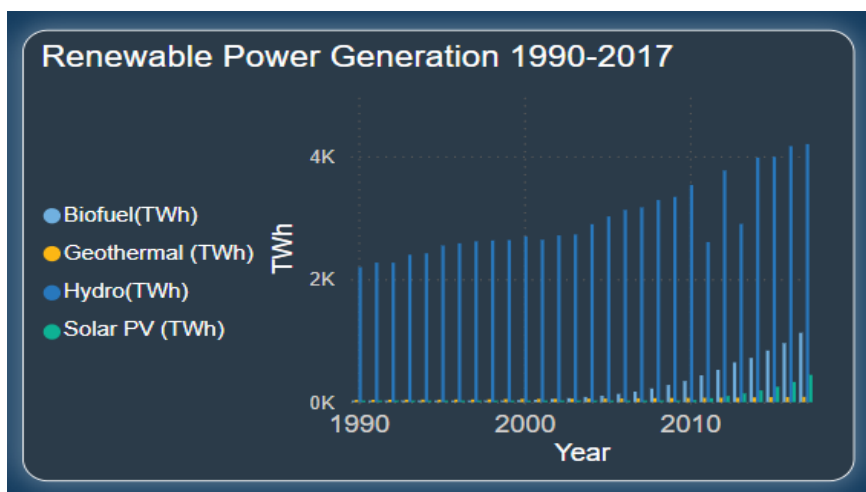
Country Average



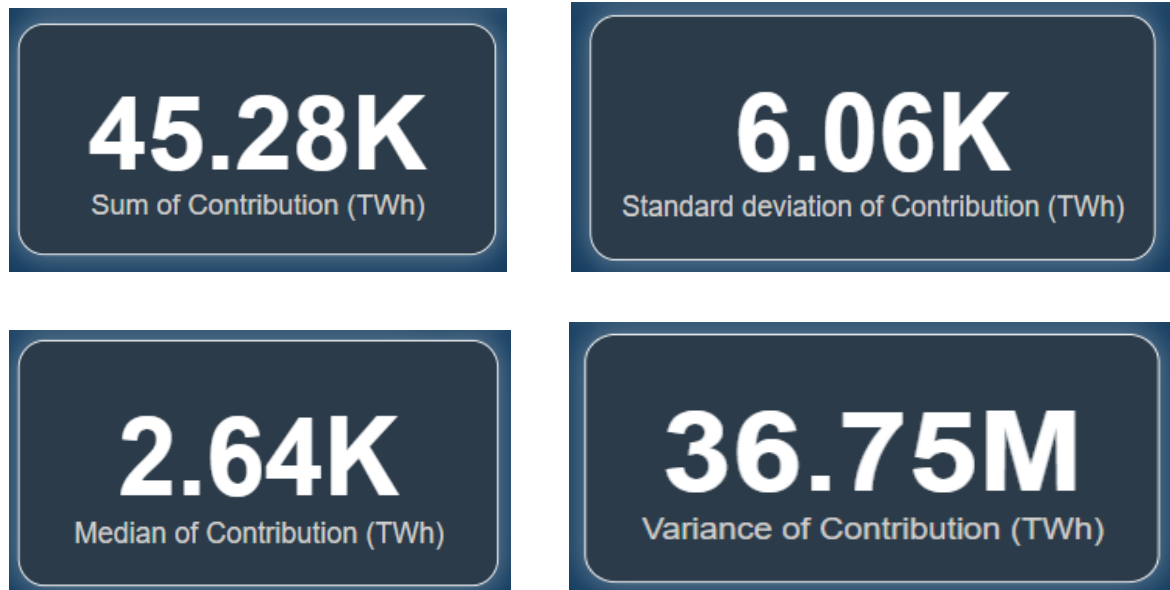
Non-Renewable Sources



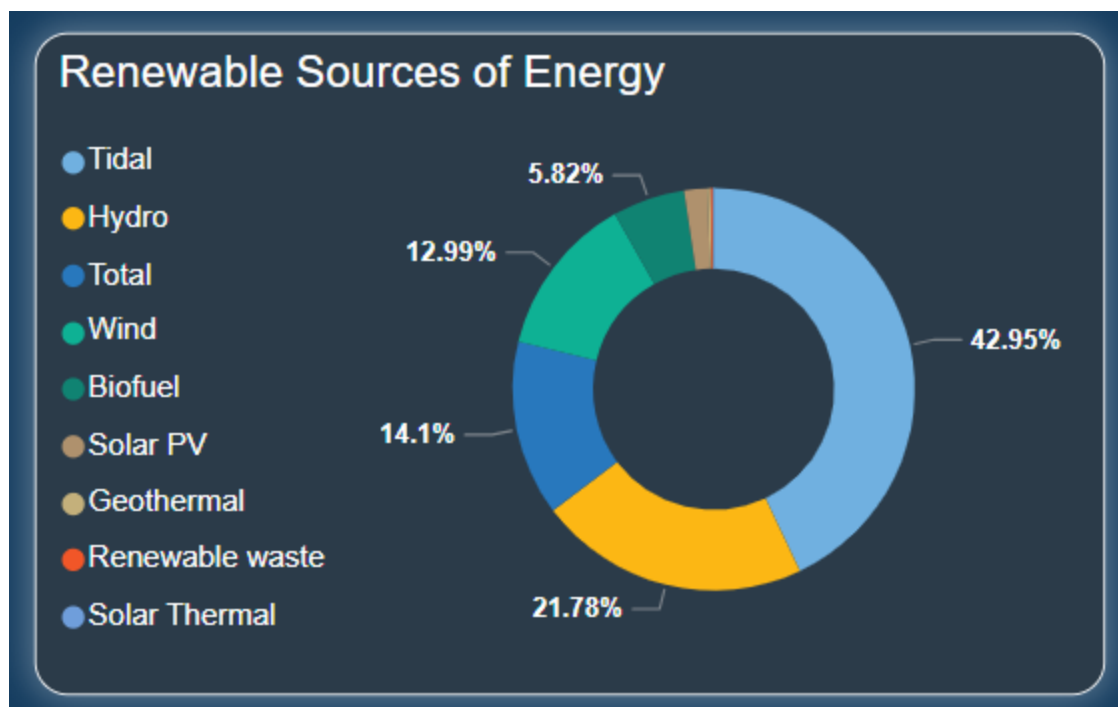
Renewable Generation 1997-2017



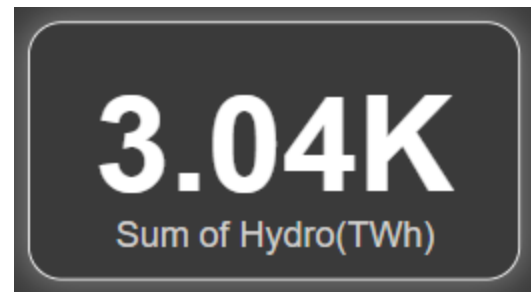
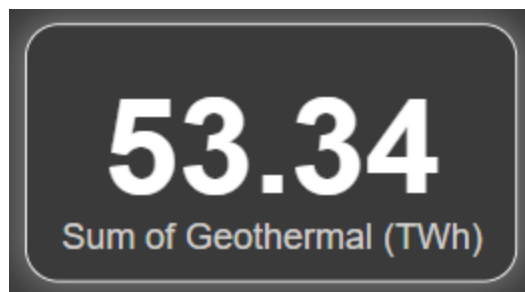
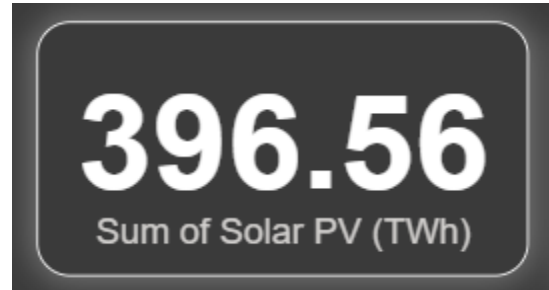
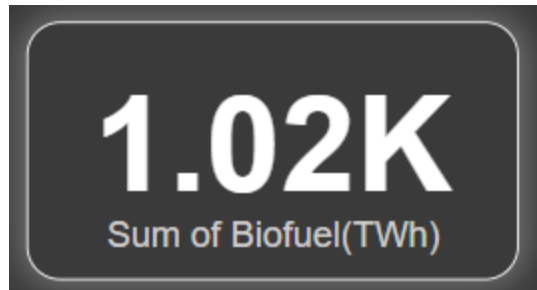
Cards- Sum, Median, Standard Deviation, and Variance of Contribution



Renewable Sources



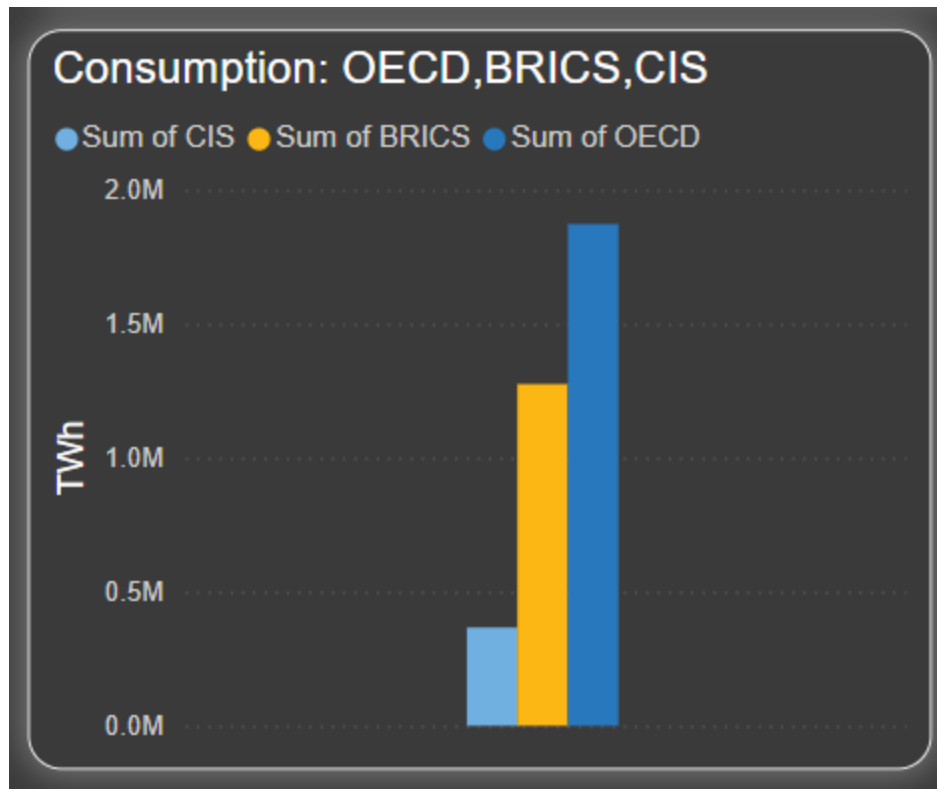
Cards - Geothermal, Bio-fuel, Hydro and Solar PV



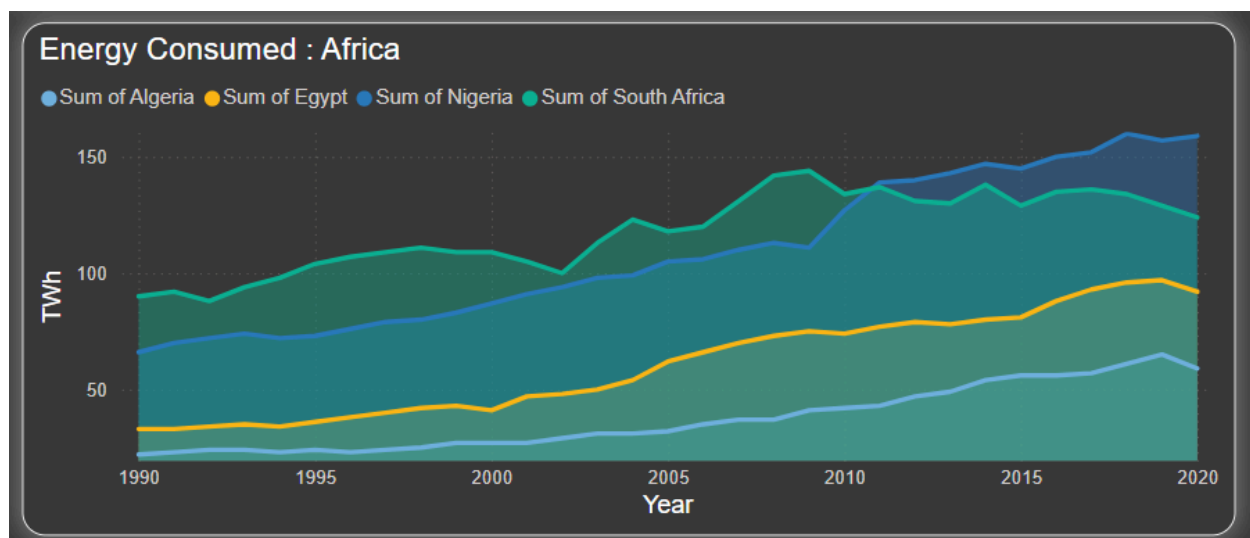
Report Narrative

- . 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 85.34(TWh), and Hydro ranged from 2,191.67(TWh) to 4,197.29(TWh)

BRICS, OECD and CIS



Energy Consumption in Africa

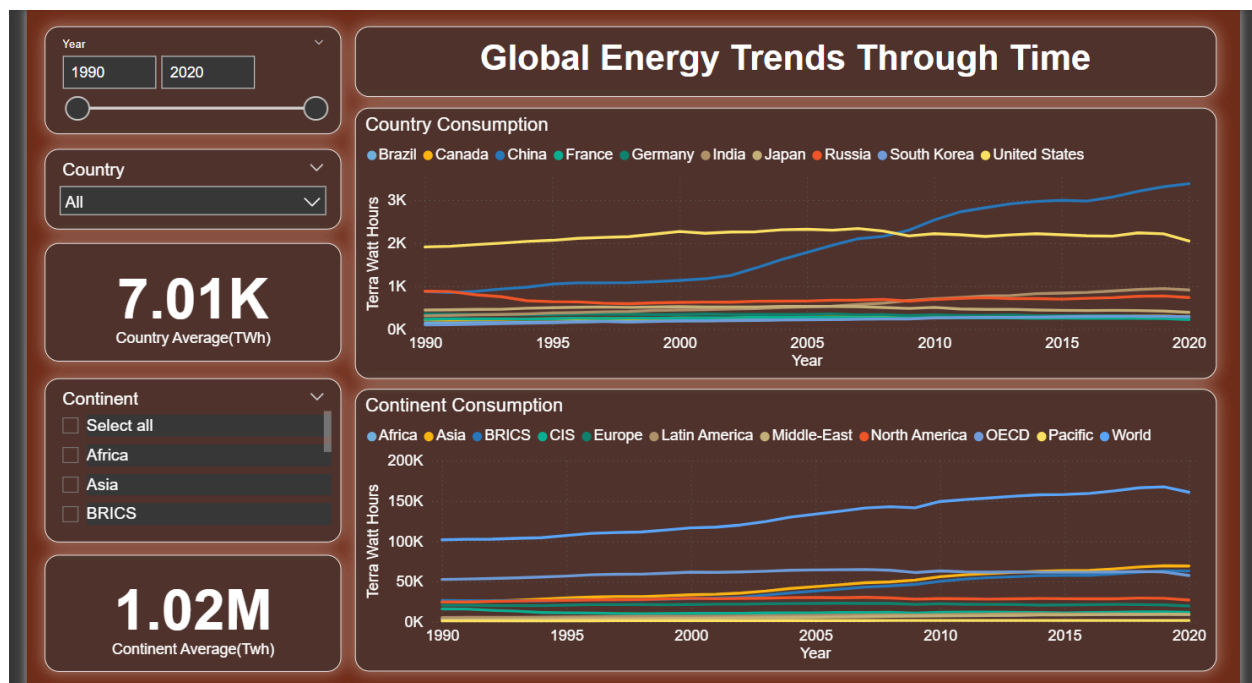


MILESTONE 4: DASHBOARD

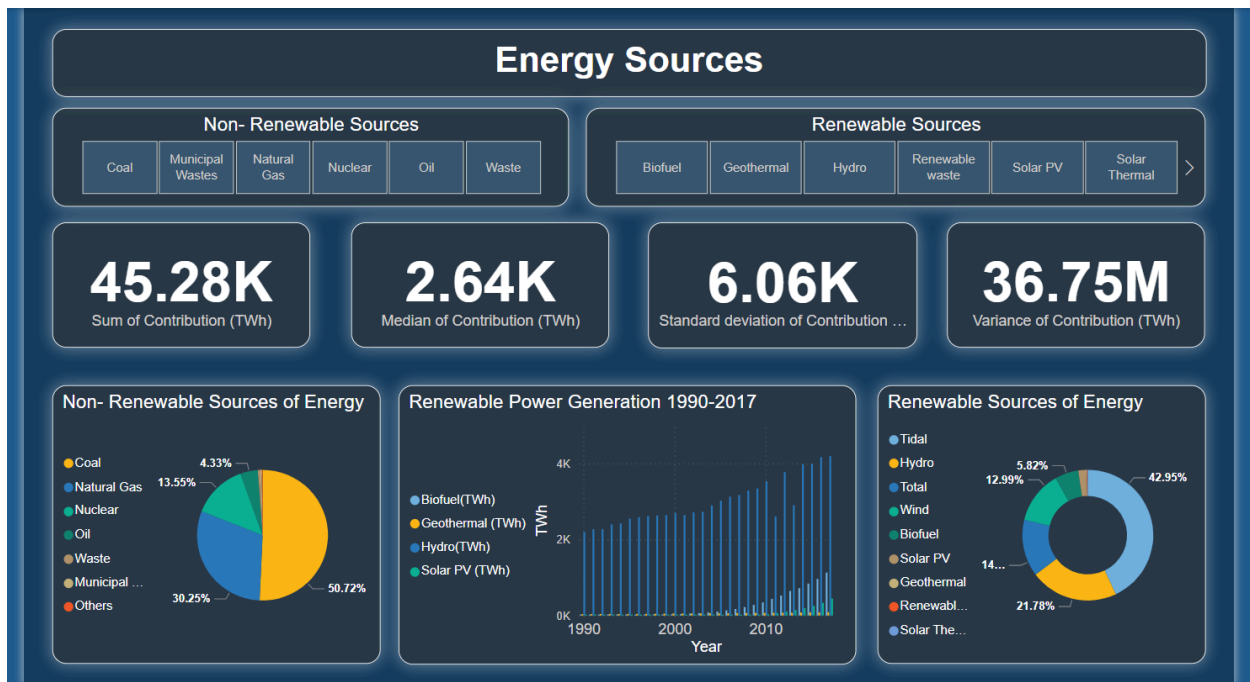
A dashboard is a graphical user interface (GUI) that displays information and data in an organized and easy-to-read format. Dashboards are often used to provide real-time monitoring and analysis of data. They are typically designed for a specific purpose or use case. Dashboards can be used in a variety 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

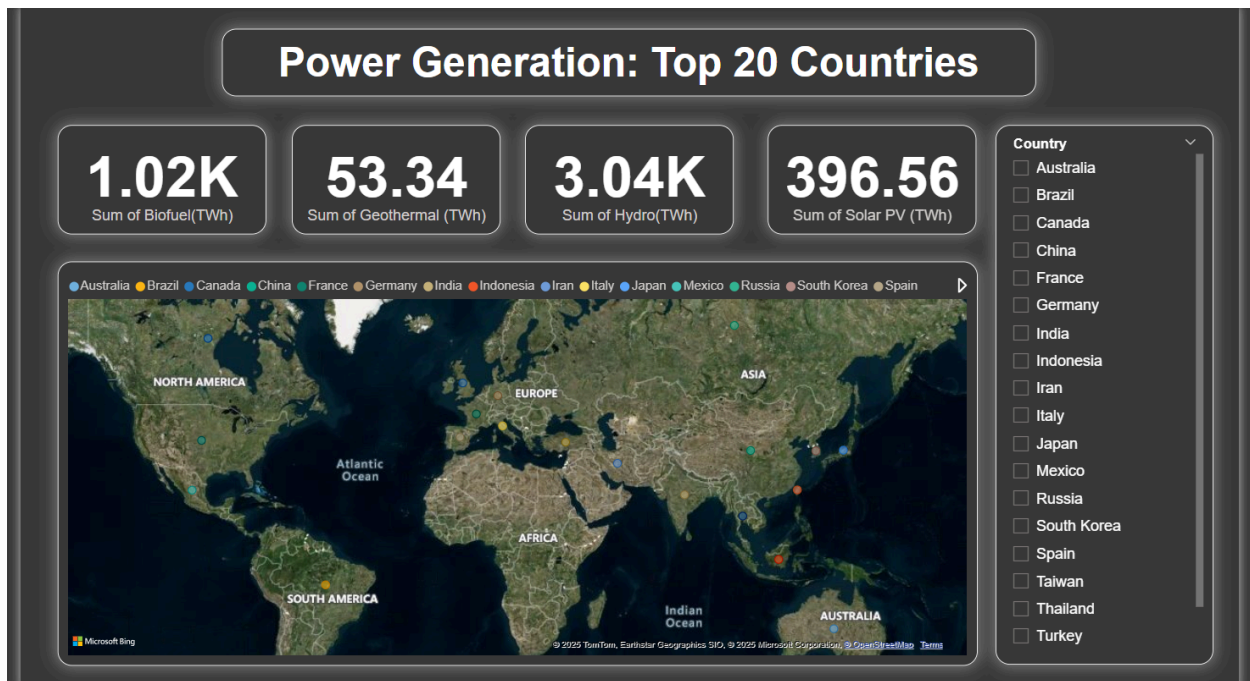
Global Energy Trends Through Time – Slicers for year, country, continent; line charts; and cards for averages.



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.

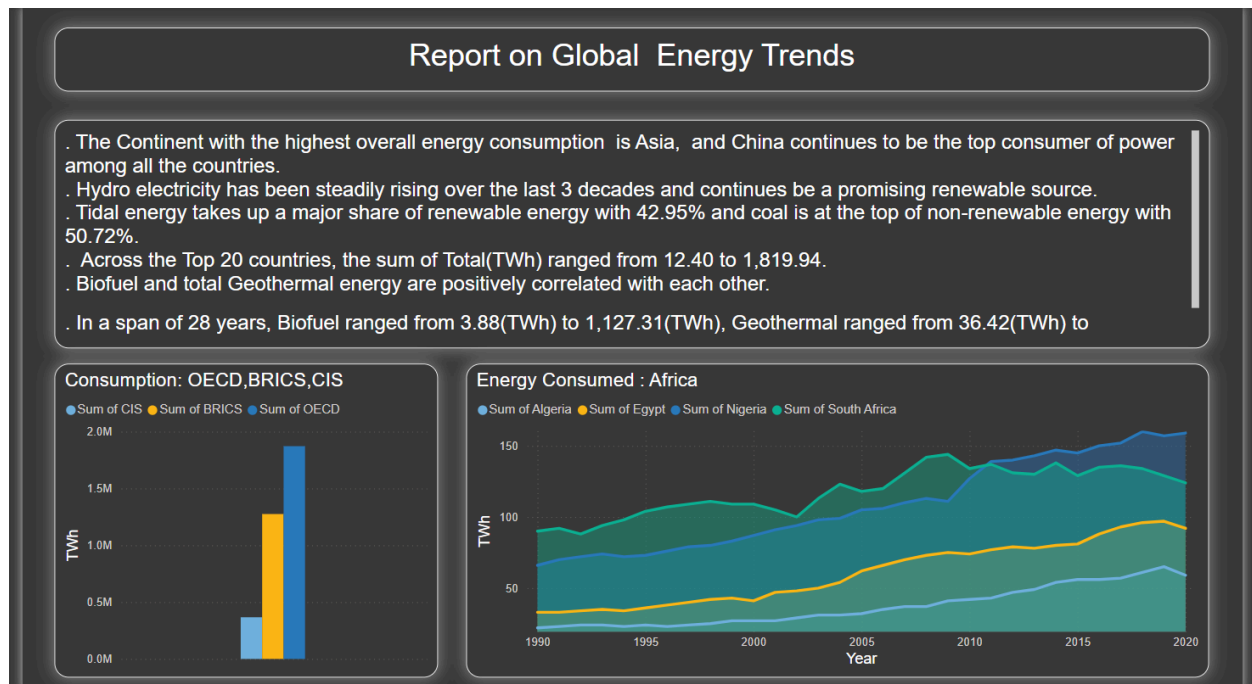


MILESTONE 5: REPORT

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.



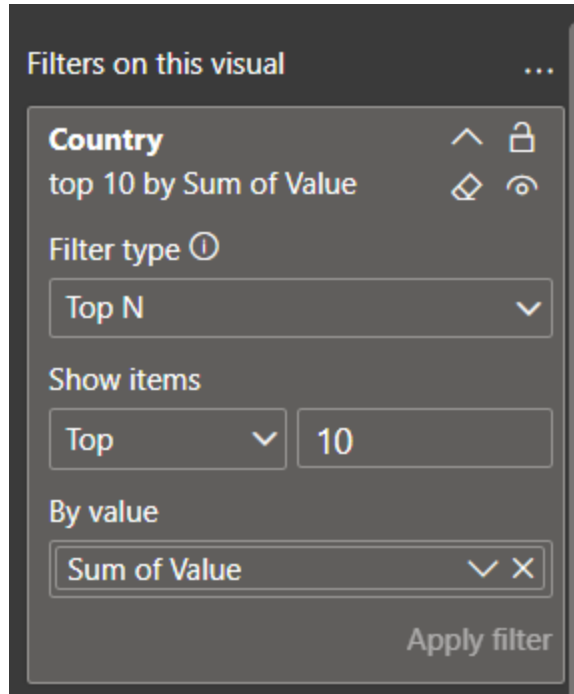
MILESTONE 6: PERFORMANCE TESTING

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

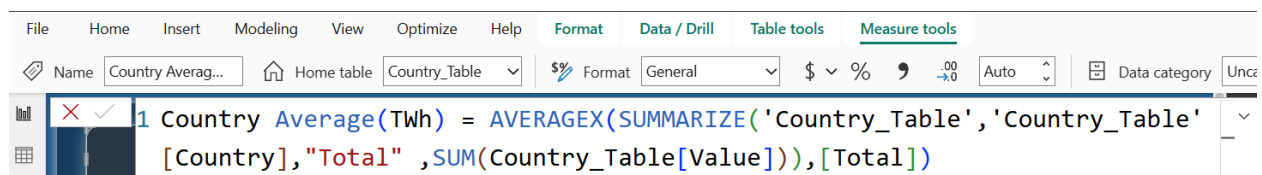
Selections within the data allow users to filter data based on individual fields or dimensions. Users can choose specific values within a field to include or exclude from analysis. Complex filters based on predefined conditions and logic can also be created.



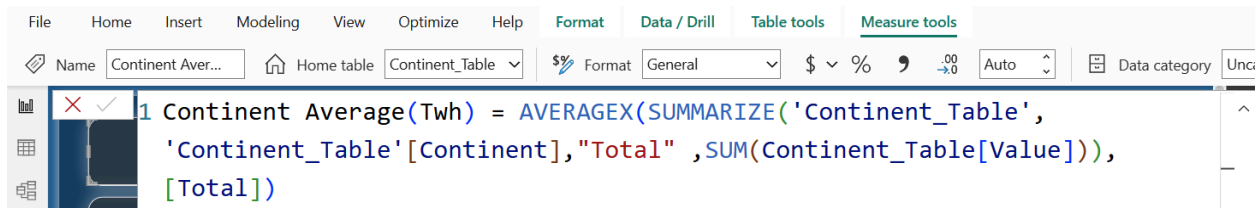
Use of Measures/Calculated Columns

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/1aE8ixtDsHZQyqEsqikRyRpKbbwZ9fteE/view?usp=sharing>