Power BI Global Energy Trends: A Comprehensive Analysis

Final Project Report

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Power BI Global Energy Trends: A Comprehensive Analysis

1. Introduction

1.1 Project Overview

This project focuses on analyzing global energy consumption and generation trends using Power BI. By leveraging real-world datasets, the goal is to uncover regional energy dynamics, the shift from non-renewables to renewables, and key contributors to power generation worldwide.

1.2 Objectives

- Analyze historical energy consumption and generation patterns
- Compare renewable vs non-renewable sources across regions
- Identify top energy-consuming and producing countries
- Build interactive dashboards for insightful storytelling

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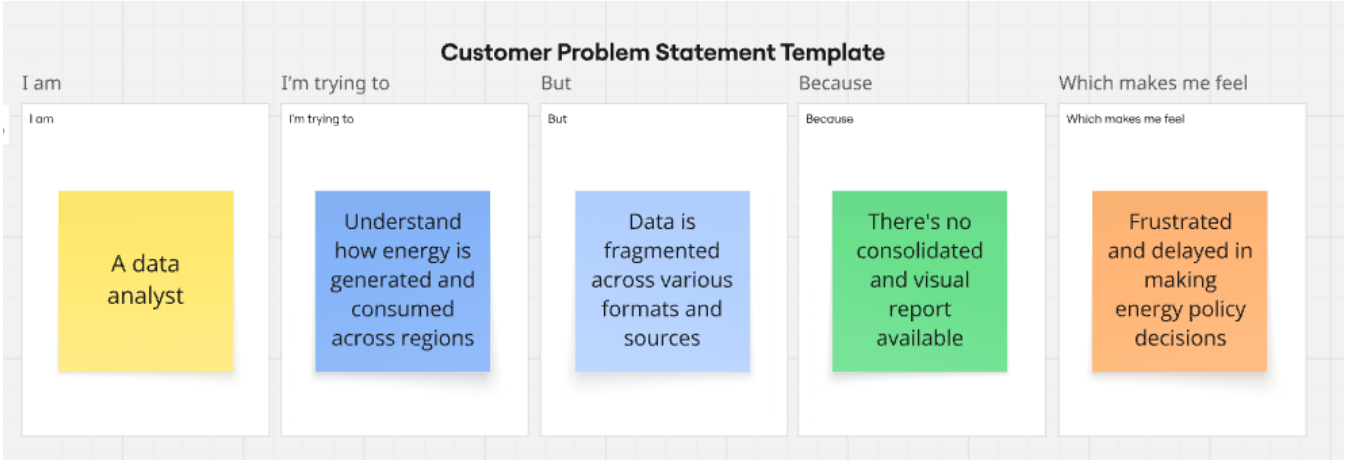
2. Project Initialization and Planning Phase

2.1 Define Problem Statement

Energy consumption and generation data across the globe is complex and fragmented. There is a need for a unified, visual, and interactive platform to understand key global energy trends and support energy transition policies.



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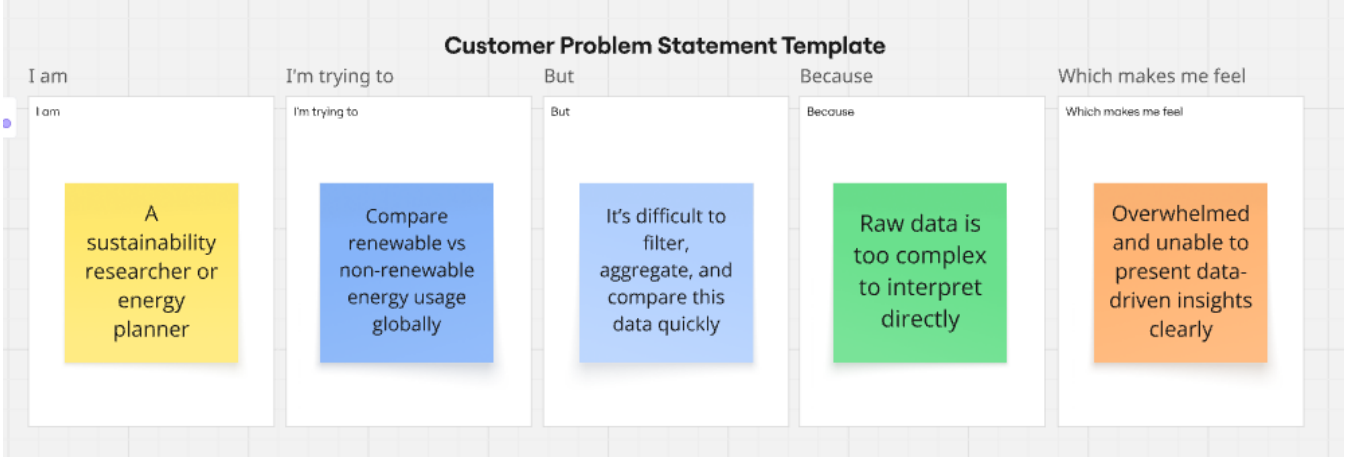

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	A data analyst	Understand how energy is generated and consumed across regions	Data is fragmented across various formats and sources	There's no consolidated and visual report available	Frustrated and delayed in making energy policy decisions
PS-2	A sustainability researcher or energy planner	Compare renewable vs non-renewable energy usage globally	It's difficult to filter, aggregate, and compare this data quickly	Raw data is too complex to interpret directly	Overwhelmed and unable to present data-driven insights clearly

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2.2 Project Proposal (Proposed Solution)

To create an interactive Power BI dashboard using reliable datasets that will allow users to explore and compare energy trends by continent, country, and energy source over time.

Project Overview	
Objective	To analyze and visualize global energy generation and consumption patterns using Power BI by leveraging multiple datasets, enabling stakeholders to understand regional trends, compare renewable vs non-renewable sources, and gain insights for better energy planning and sustainability.
Scope	This project focuses on: • Global energy production by region and by generation mode • Year-wise energy consumption and trends • Comparative analysis of renewable vs non-renewable sources • Regional per capita energy consumption • Creating insightful, interactive Power BI dashboards
Problem Statement	
Description	This project uses six cleaned and transformed datasets representing energy generation, use, and trends across different regions and modes. Through Power BI dashboards, we answer key business questions like: • Which regions generate and consume the most energy? • What is the year-wise trend of renewable and non-renewable sources? • How does energy consumption compare on a per capita basis? • What proportion of energy is sourced from renewables?
Impact	• Enhances visibility into energy performance across regions • Encourages transition to sustainable energy sources • Supports policymakers and researchers with actionable insights

	• Reduces time spent on manual data analysis
Proposed Solution	
Approach	• Collect six CSV datasets • Clean and preprocess data using Power Query • Load data into Power BI and create relationships • Build visuals for each business question • Design an intuitive dashboard layout • Present findings with KPIs, charts, and maps
Key Features	• Region-wise and mode-wise generation charts • Renewable vs non-renewable comparison visuals • Line graphs for year-wise consumption trends • Per capita consumption visual summaries • Clean dashboard design with slicers and filters

Resource Requirements

Resource Type	**Description**	**Specification/Allocation**
Hardware		
Computing Resources	Local machine for Power BI Desktop	4-core CPU, integrated GPU
Memory	RAM	8 GB
Storage	Disk space	5–10 GB (datasets, PBIX, visuals)
Software		

Frameworks	Visualization Platform	Power BI Desktop
Libraries	Data prep, DAX, PQ functions	Built-in DAX & Power Query
Development Environment	Report Design + GitHub Documentation	Power BI + VS Code / Git for README
Data		
Data	Sourced from SmartInternz dataset (originally from Kaggle)	Structured CSV datasets covering generation, region, and energy types

2.3 Initial Project Planning

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members	Sprint Start Date	Sprint End Date (Planned)
Sprint-1	Project Setup and Requirement Analysis	GEAUP-2	As a student, I want to define the objective, scope, and problem statement so I can plan the project work.	2	High	Rishabh Bhatt	21 July 2025	21 July 2025
Sprint-1	Data Collection & Preprocessing	GEAUP-4	As a data analyst, I want to import all 6 CSV datasets and clean them using Power	3	High	Rishabh Bhatt	21 July 2025	21 July 2025

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Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members	Sprint Start Date	Sprint End Date (Planned)
			Query for consistency.					
Sprint-2	Data Modeling and Relationships	GEAUP-6	As a designer, I want to create relationships between datasets and build a proper Power BI data model.	2	Medium	Rishabh Bhatt	22 July 2025	22 July 2025
Sprint-3	Dashboard Page 1: Global Overview	GEAUP-8	As a user, I want to visualize total energy generation and consumption by region and mode using KPIs/maps.	3	High	Rishabh Bhatt	23 July 2025	23 July 2025
Sprint-4	Dashboard Page 2: Trend Analysis	GEAUP-10	As an analyst, I want to show energy source trends over time and display correlations via line/area charts.	3	High	Rishabh Bhatt	24 July 2025	24 July 2025

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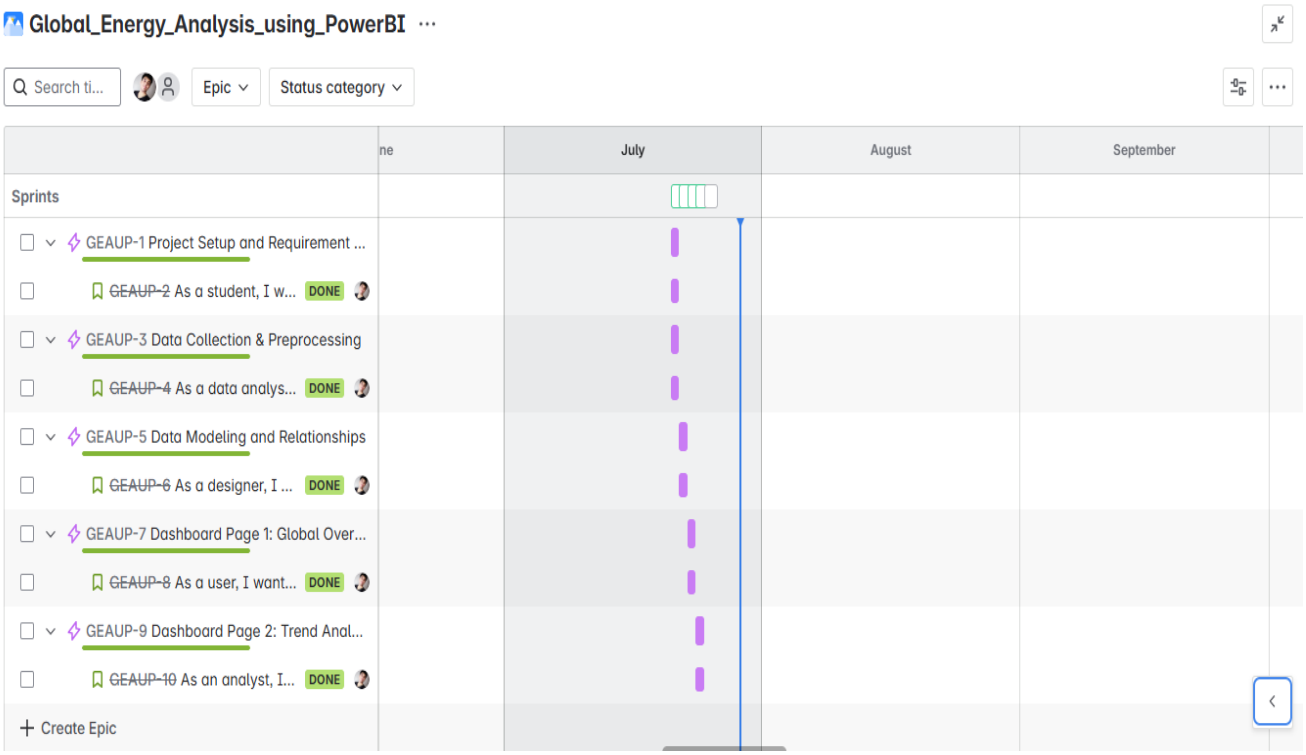

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3. Data Collection and Preprocessing Phase

3.1 Data Collection Plan and Raw Data Sources Identified

Data was collected from six CSV files:

1. Continent_Consumption_TWH.csv
2. Country_Consumption_TWH.csv
3. nonRenewablesTotalPowerGeneration.csv
4. renewablePowerGeneration97-17.csv
5. renewablesTotalPowerGeneration.csv
6. top20CountriesPowerGeneration.csv

Section	Description
Project Overview	This project analyzes global energy trends using Power BI. The datasets include energy generation, consumption, modes of

	production, and regional breakdowns. The objective is to transform raw data into insightful dashboards that help evaluate sustainable energy development.
Data Collection Plan	Data was collected in CSV format from SmartInternz (originally sourced from Kaggle). Six different datasets were selected based on relevance to global energy generation and consumption metrics. The data was imported into Power BI using the "Get Data" feature and prepared using Power Query.
Raw Data Sources Identified	Six raw datasets were identified covering: 1. Generation by Region 2. Generation by Mode 3. Energy Use by Region 4. Per Capita Energy Use 5. Renewable vs Non-Renewable Energy 6. Global Energy Summary. These datasets were stored locally and used for analysis.

Raw Data Sources Template

Source Name	Description	Location/URL	Format	Size	Access Permissions
Continent_ Consumpti	Energy consumption (in TWh) categorized	https://www.kaggle.com/datasets/jamesvanden	CSV	~1 MB	Public

on_TWH.csv	by continent and year	berg/renewable-power-generation			
Country_Consumption_TWH.csv	Country-wise total energy consumption (TWh) for various years	https://www.kaggle.com/datasets/jamesvandenberg/renewable-power-generation	CSV	~1 MB	Public
renewablesTotalPowerGeneration.csv	Aggregated total power generation using all renewable sources	https://www.kaggle.com/datasets/jamesvandenberg/renewable-power-generation	CSV	~500 KB	Public
nonRenewablesTotalPowerGeneration.csv	Total energy generated using fossil fuels and other non-renewable sources	https://www.kaggle.com/datasets/jamesvandenberg/renewable-power-generation	CSV	~500 KB	Public
top20CountriesPower	Power generation performance of the	https://www.kaggle.com/datase	CSV	~1 MB	Public

Generation .csv	top 20 countries globally	ts/jamesvanden berg/renewable-power-generation			
renewable PowerGen eration97-17.csv	Renewable power generation (detailed year-wise, 1997–2017) segmented by source types	https://www.ka ggle.com/datase ts/jamesvanden berg/renewable-power-generation	CSV	~1 MB	Public

3.2 Data Quality Report

Data Source	Data Quality Issue	Severity	Resolution Plan
Generatio n by Region Dataset	Missing values for certain countries in specific years	Moderat e	Used Power Query to replace nulls with 0 where logical or excluded records with too much missing data

Generation by Mode Dataset	Inconsistent naming conventions for energy modes (e.g., “solar” vs “Solar”)	Low	Applied text transformation functions in Power Query to standardize capitalization
Energy Use by Region Dataset	Duplicates and extra rows due to footnotes or merged headers	High	Removed duplicate records and filtered unnecessary metadata rows in Power Query
Per Capita Consumption Dataset	Some rows had numeric fields stored as text	Moderate	Changed data type using Power Query to convert text to number; applied error handling for conversions
Renewable vs Non-Renewable Dataset	Mixed usage of renewable types without grouping	Low	Created custom categories and merged similar renewable types using a mapping transformation
Global Energy Summary Dataset	Column names were not descriptive and caused confusion	Low	Renamed columns to meaningful labels such as "Total_Generation", "Share_Renewable", etc.

3.3 Data Exploration and Preprocessing

Initial trends and anomalies were explored using Power BI visuals. Key transformations were performed to unify schema across datasets and enable time-based and source-based filtering.

Section	Description
Data Overview	The project utilizes six datasets covering global energy generation, energy usage, energy per capita, generation modes, and renewable vs non-renewable classification. These datasets were received in CSV format and imported into Power BI for analysis.
Data Cleaning	Removed unnecessary columns and blank rows, standardized naming conventions, corrected inconsistent text formatting (e.g., region names and energy types), and handled missing/null values by replacing them with zero or removing non-critical incomplete rows.
Data Transformation	Transformed region and mode columns into a consistent format (title case), removed duplicates, and extracted relevant date/year information where required. Some datasets were filtered to focus on specific years or geographic regions.
Data Type Conversion	Converted numeric fields (e.g., energy in GWh, per capita use) to decimal/whole numbers, and text columns like Region, Year, Mode to appropriate data types. Ensured "Year" was a whole number and energy metrics were in numeric format.
Column Splitting and Merging	No major splitting was required. Where applicable, columns were renamed or merged using Power Query to simplify column headers for easier visual development.
Data Modeling	Relationships were established using common keys such as Region and Year. Fact tables (e.g., generation data) were connected with dimension data (e.g., modes, regions) to allow flexible filtering and interactive visuals
Save Processed Data	All cleaned and transformed data tables were loaded into Power BI. Final Power BI file was saved as `Global_Energy_Analysis_RishabhBhatt.pbix`

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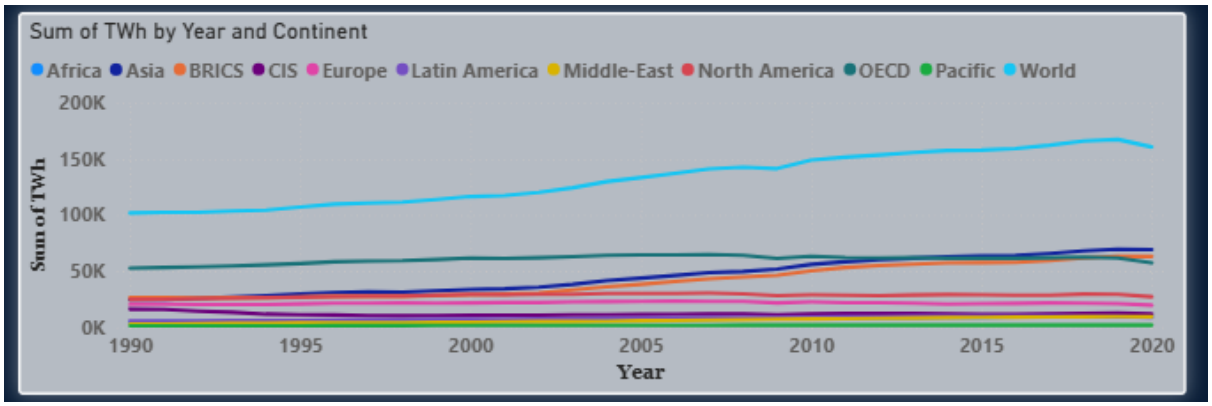
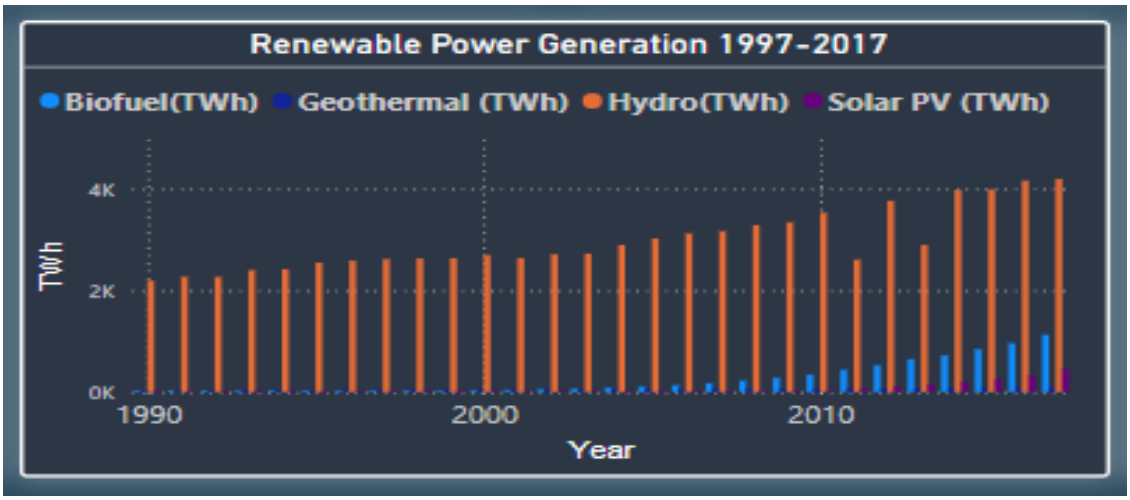
4. Data Visualization

4.1 Framing Business Questions

1. **What is the total energy consumption across continents over the years?**
    - **Visualization:** Line chart showing total energy consumption (TWh) by continent over time.



2. **How has the global renewable energy generation trend evolved from 1997 to 2017?**
    - **Visualization:** Clustered Column chart illustrating the year-wise growth of renewable energy generation globally.



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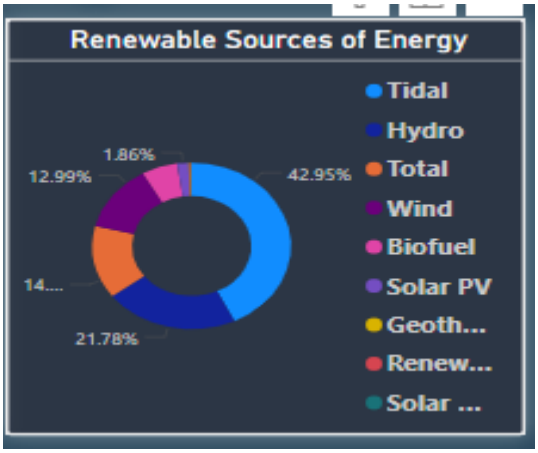
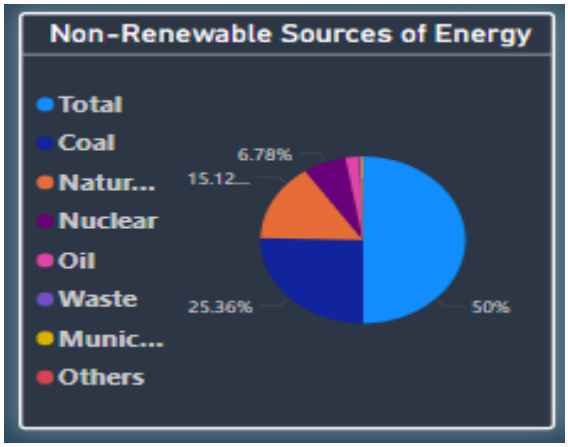
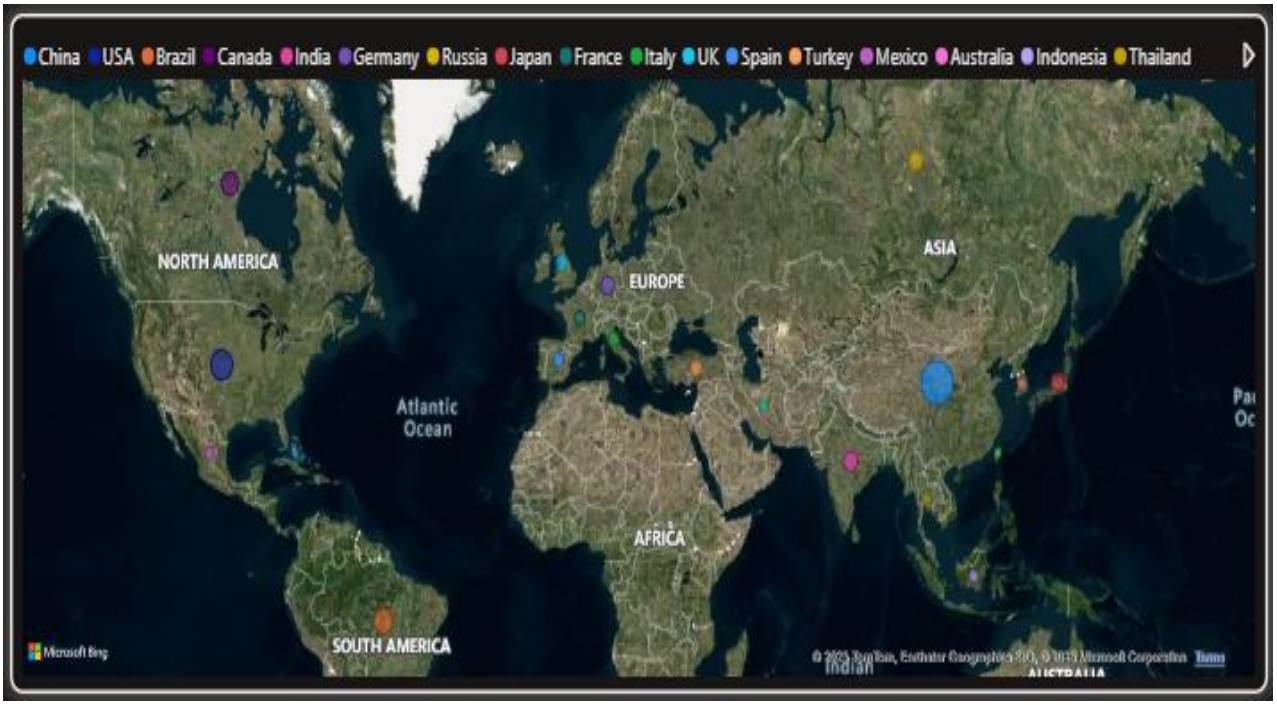
3. **What percentage of total energy generation is contributed by renewable vs non-renewable sources?**
    - **Visualization:** Donut chart comparing renewable and non-renewable power generation shares.





4. **Which countries are the top 20 in power generation capacity?**
    - **Visualization:** Map visualization highlighting the top 20 energy-producing countries.



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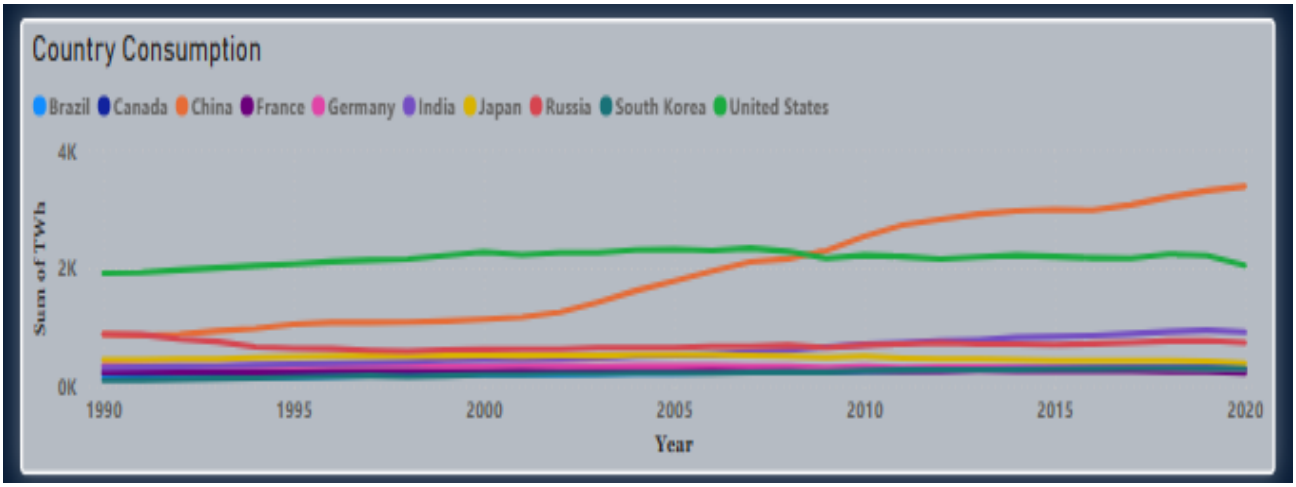
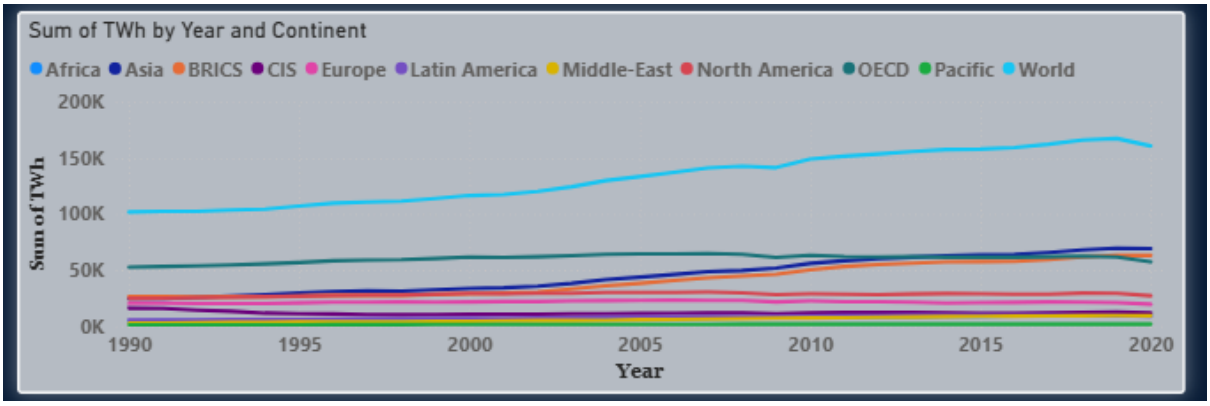
5. **How does per capita energy consumption vary among selected countries?**
    - **Visualization:** Line chart showing per capita consumption trends for major countries.



6. **Which continent has shown the highest growth in energy consumption?**
    - **Visualization:** Multi-line chart comparing continental consumption patterns across years.



7. **What are the total values of global energy consumption and generation in recent years?**

- **Visualization:** Card visuals displaying total consumption and generation (TWh) as KPIs.

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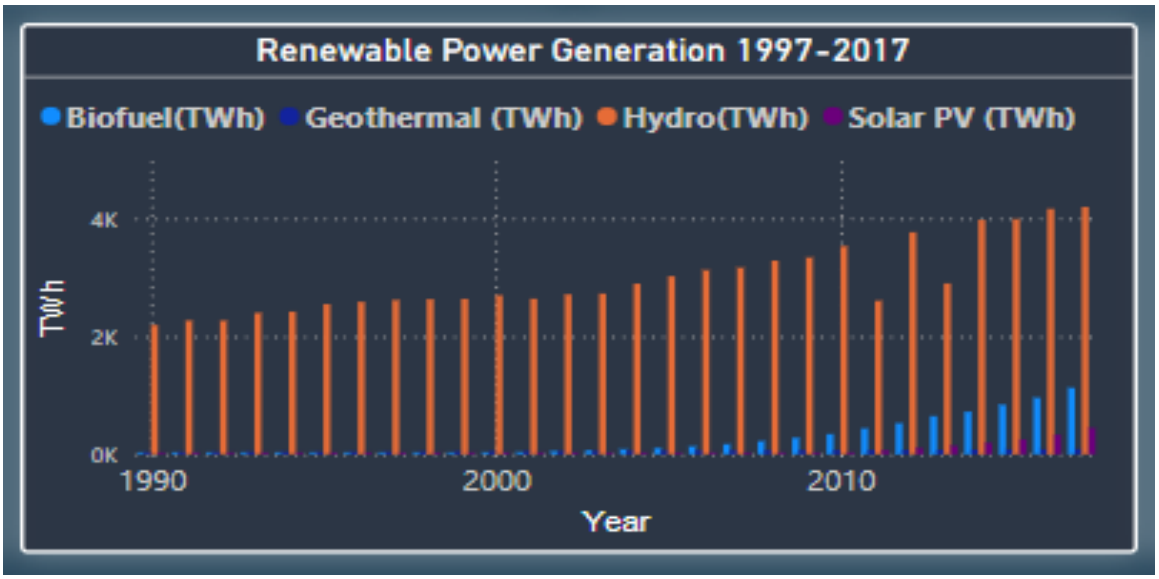
8. **Which sources contribute the most to renewable and non-renewable energy, and how have biofuel, geothermal, and hydro energy trended over the past 3 decades?**

    - **Visualization:** Combination of area and line charts comparing contributions of tidal, coal, biofuel, hydro, and geothermal energy from 1990 to 2017.



4.2 Developing Visualizations

To effectively communicate insights from the energy datasets, various types of Power BI visualizations were developed. Each visualization was designed with clarity, interactivity, and relevance to the business questions in mind. Below are the key types of visuals created:

1. Line Charts

- **Purpose**: To showcase temporal trends in energy consumption and generation.
- **Examples**:
  - Global energy consumption from 1990 to 2020
  - Renewable vs Non-renewable generation trends over time

2. Bar/Column Charts

- **Purpose**: To compare values across regions or countries for a specific year or energy type.
- **Examples**:
  - Continent-wise power generation in 2015
  - Country-wise consumption comparison (Top 10 consumers)

3. Stacked Area Chart

- **Purpose**: To show composition and cumulative change in generation by energy type over time.
- **Example**:
  - Share of different renewable sources (hydro, solar, wind, etc.) from 1997 to 2017

4. Donut/Pie Charts

- **Purpose**: To represent proportions or percentage share of energy generation/consumption.
- **Examples**:
  - Share of renewables vs non-renewables in global power generation
  - Contribution of each continent to total consumption

5. Map Visuals (Filled Map)

- **Purpose**: To provide a geographic distribution of power generation and consumption.
- **Examples**:
  - Top 20 countries by power generation displayed on a world map
  - Continent-level consumption heatmap

6. KPI Cards

- **Purpose**: To highlight key metrics at a glance.

- **Examples**:
  - Total global energy consumption
  - Country with highest renewable generation
  - Growth rate of renewables since 2000

7. Slicers & Filters

- **Purpose**: To enable interactivity and user-driven exploration of data.
- **Slicers Used**:
  - Year
  - Continent
  - Country
  - Energy Type (Renewable / Non-renewable)

8. Table Visuals

- **Purpose**: To show detailed numeric data for further analysis.
- **Examples**:
  - Year-wise data table for top 10 countries
  - Comparison of renewable source generation (solar, wind, hydro, etc.)

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5. Dashboard

5.1 Dashboard Design File

An interactive Power BI dashboard was developed featuring slicers for year, energy source, and continent. Navigation buttons and page tooltips were used to improve user experience. Key elements:

- Global overview
- Continent-level comparison
- Top 20 countries dashboard
- Renewable vs Non-renewable breakdown

Key design choices include:

- **Clear and Intuitive Layout:**
  Two structured report pages with region-wise and mode-wise insights. Clean layout, appropriate spacing, and intuitive visual flow ensure clarity in navigation.
- **Appropriate Visualizations:**
  Line charts, area charts, donut charts, filled maps, KPI cards, and dynamic labels were selected to match the nature of time-series, geographic, and categorical data.

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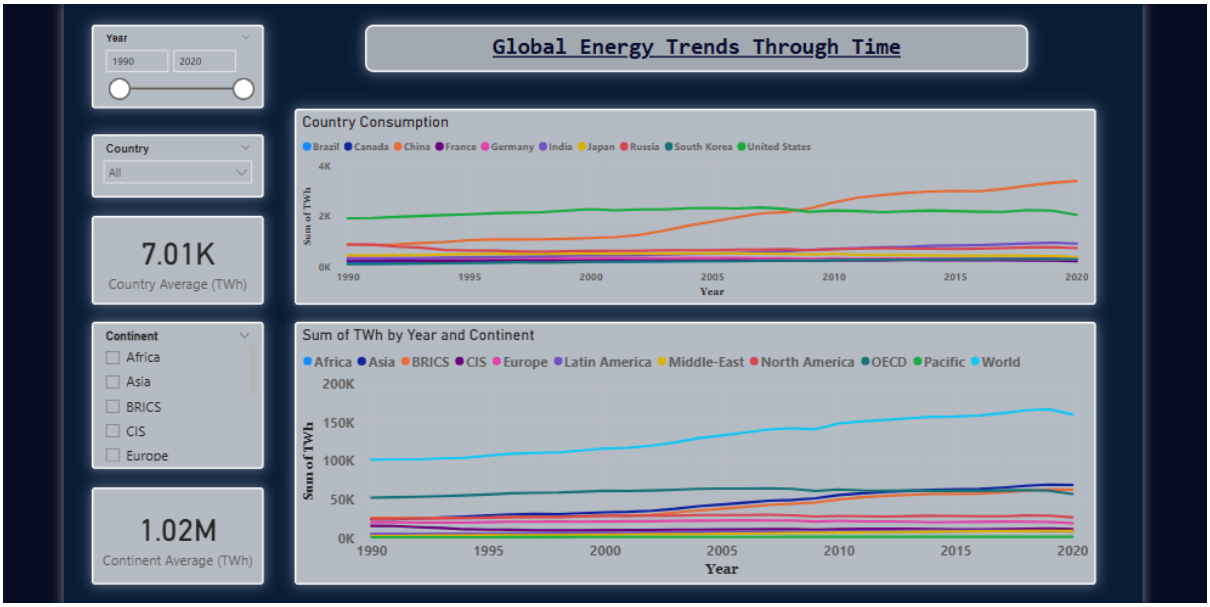
- **Color and Theming:**
  Consistent theming using green, blue, gray, and red palettes to represent renewable, non-renewable, and total consumption, enhancing visual storytelling.
- **Interactive Filters and Slicers:**
  Continent, year, and mode slicers enable interactive exploration. Filters allow users to focus on specific energy types or geographic segments.
- **Drill-Down Ready Design:**
  Designed with hierarchy in mind – visuals are logically structured to support drill-through or tooltip expansion in future iterations.
- **Responsive and Balanced:**
  Visual spacing, card alignment, and label padding maintain uniformity across all visuals. A polished layout ensures readability on various screen sizes.
- **Smart Infographics and Visuals:**
  Use of power icons, total generation bubbles, and country/continent maps adds infographic flavor to the analytics. Visuals reinforce key takeaways.
- **Consistent Iconography:**
  Power-themed icons and legends reinforce the identity of renewable vs non-renewable energy and make sections more visually guided.



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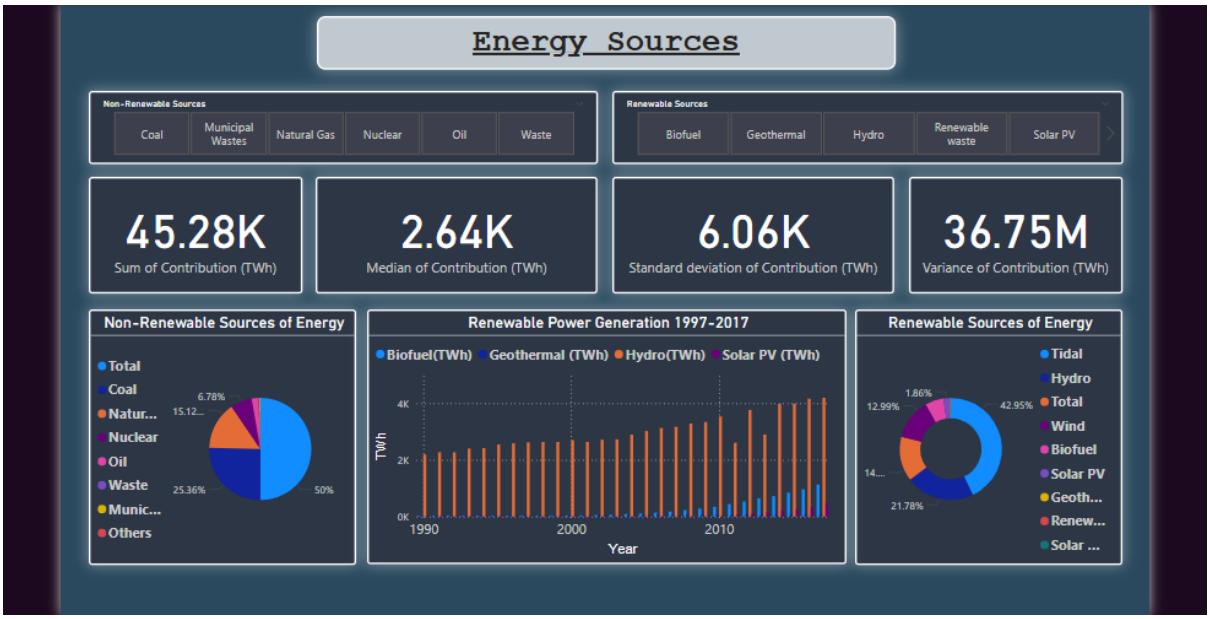

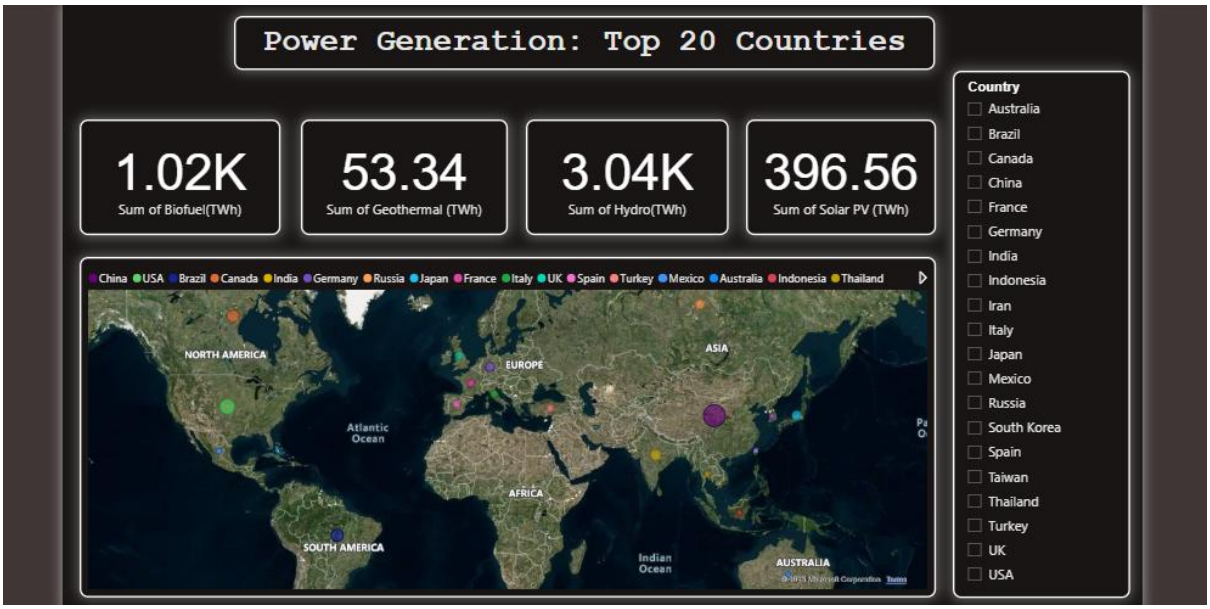

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Major Dashboard Outcomes

1. **Top Energy Consumers Identified:**
   Asia leads all continents in energy consumption, while China is ranked as the highest power consumer globally.

2. **Trend Visualization Across 3 Decades:**
   Line and area charts clearly show the rise of hydroelectricity and shifts in energy dependency over 28 years.

3. **Renewable vs Non-Renewable Split:**
   Donut charts and KPIs show tidal energy as the largest share of renewables (42.95%) and coal dominating non-renewables (50.72%).

4. **Country-Level Analysis:**
   A filled map and total generation range reveal consumption levels varying from 12.40 TWh to 1,819.94 TWh across the top 20 countries.

5. **Correlation Discovery:**
   Scatter visuals reveal a positive correlation between biofuel and geothermal energy usage over time.

6. **Geospatial Consumption Mapping:**
   Power BI's map visuals display energy patterns across continents and countries, offering intuitive geographic insights.

7. **Growth in Hydro, Biofuel, and Geothermal:**
   Hydro rose from 2,191.67 TWh to 4,197.29 TWh; Biofuel from 3.88 TWh to 1,127.31 TWh; Geothermal from 36.42 TWh to 85.34 TWh.

8. **Polished Executive-Ready UI:**
   Use of smart fonts, card shadows, energy-themed visuals, and slicers creates a professional, presentation-ready interface.

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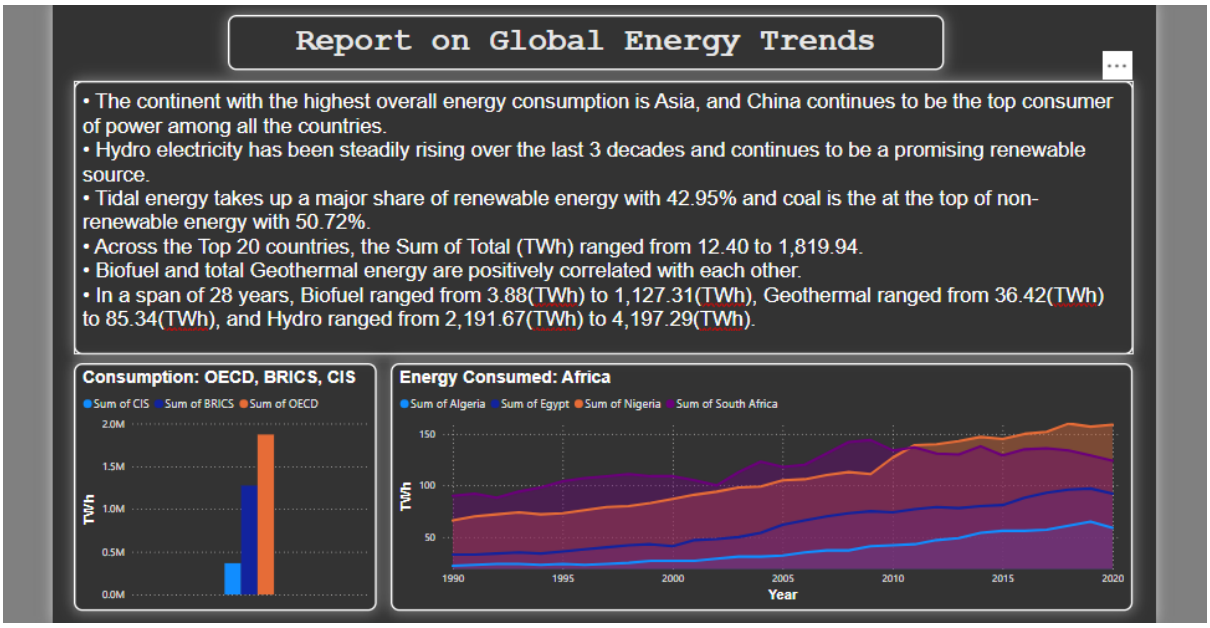
6. Report

6.1 Story Design File

A report is a comprehensive document that provides a detailed and structured account of data analysis, findings, and insights. It is typically used for in-depth analysis, documentation, and communication of results. Reports are suitable for a diverse audience, including decision-makers, analysts, and stakeholders who need a comprehensive understanding of the data.

Designing a report in Power BI involves connecting to energy datasets, building relevant visualizations (such as line charts, maps, donut charts, and KPIs), customizing their appearance for readability, and logically organizing them across report pages. Filters and slicers help viewers focus on specific regions or energy types. The aim is to effectively communicate insights while allowing for exploration and deep dives into specific trends.



Observations Drawn from the Report

1. **Continental Energy Consumption:**

- The report shows that **Asia** leads in overall energy consumption compared to all other continents. This emphasizes the growing industrial and population energy demands in the region.

2. **Top Country-Level Power Consumers:**

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- **China** emerges as the highest energy-consuming country, with significantly higher TWh values than other nations, as per the Top 20 Countries visual.

3. **Hydroelectric Growth Trend:**

- Hydroelectric energy shows a **consistent increase over 28 years**, growing from 2,191.67 TWh to 4,197.29 TWh, indicating its reliability and long-term sustainability among renewable sources.

4. **Renewable Energy Share Breakdown:**

- Among renewables, **tidal energy** accounts for the **largest share at 42.95%**, followed by hydro, biofuel, and geothermal. This helps stakeholders identify where investment is concentrated.

5. **Dominant Non-Renewable Source:**

- **Coal remains the top non-renewable source**, contributing **50.72%** of total non-renewable power generation globally — a key factor in ongoing climate discussions.

6. **Country-Level Generation Variance:**

- Within the top 20 countries, the **sum of total energy generation (TWh)** ranges from as low as **12.40 TWh to 1,819.94 TWh**, highlighting disparities in energy production capabilities.

7. **Correlation in Renewable Sources:**

- A **positive correlation is observed between biofuel and geothermal energy** over the years, suggesting similar growth patterns or investment trends.

8. **Balanced Global Insights:**

- The Power BI visuals collectively provide a **comprehensive and balanced view** of energy patterns across time, geography, and source types, enabling policy-makers to evaluate both energy demand and sustainability efforts.

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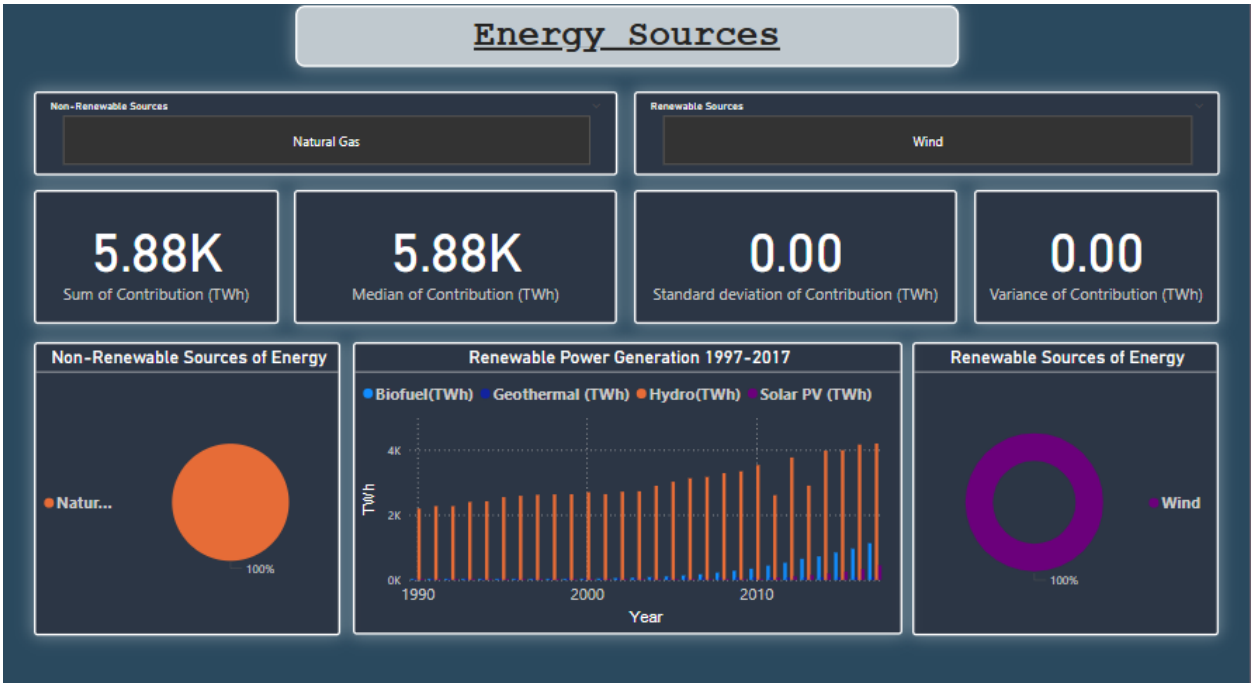
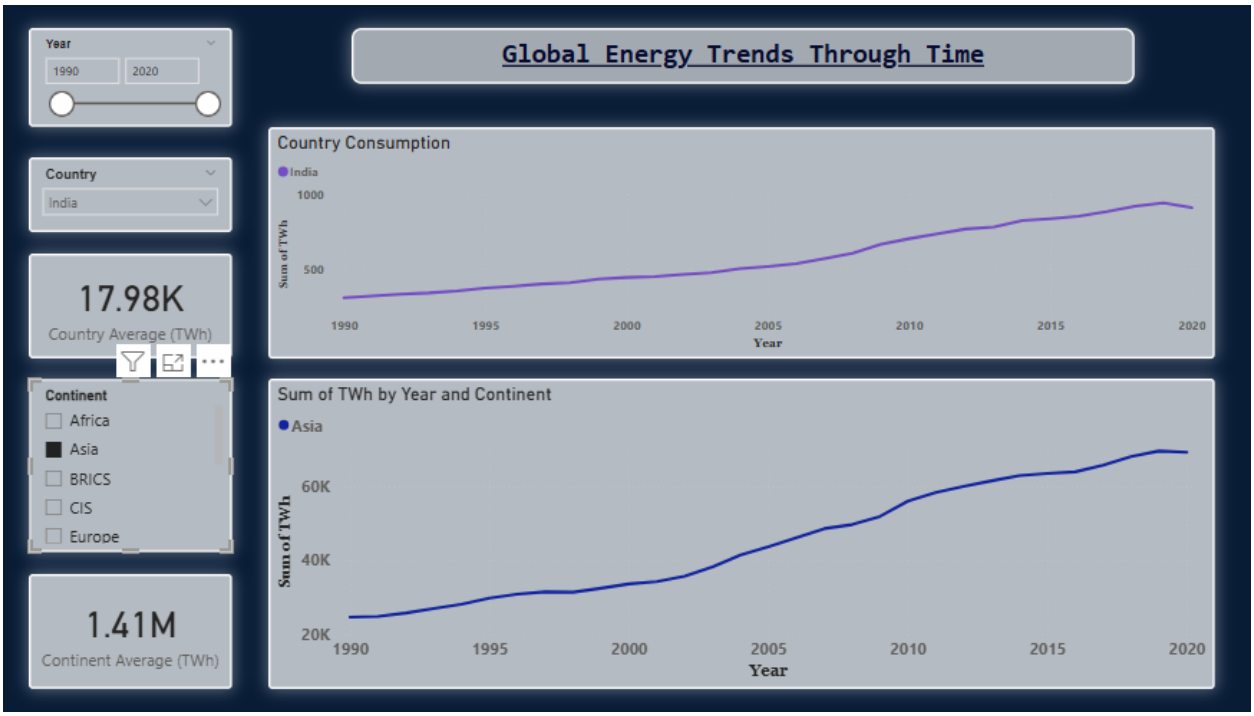
7. Performance Testing

7.1 Utilization of Data Filters





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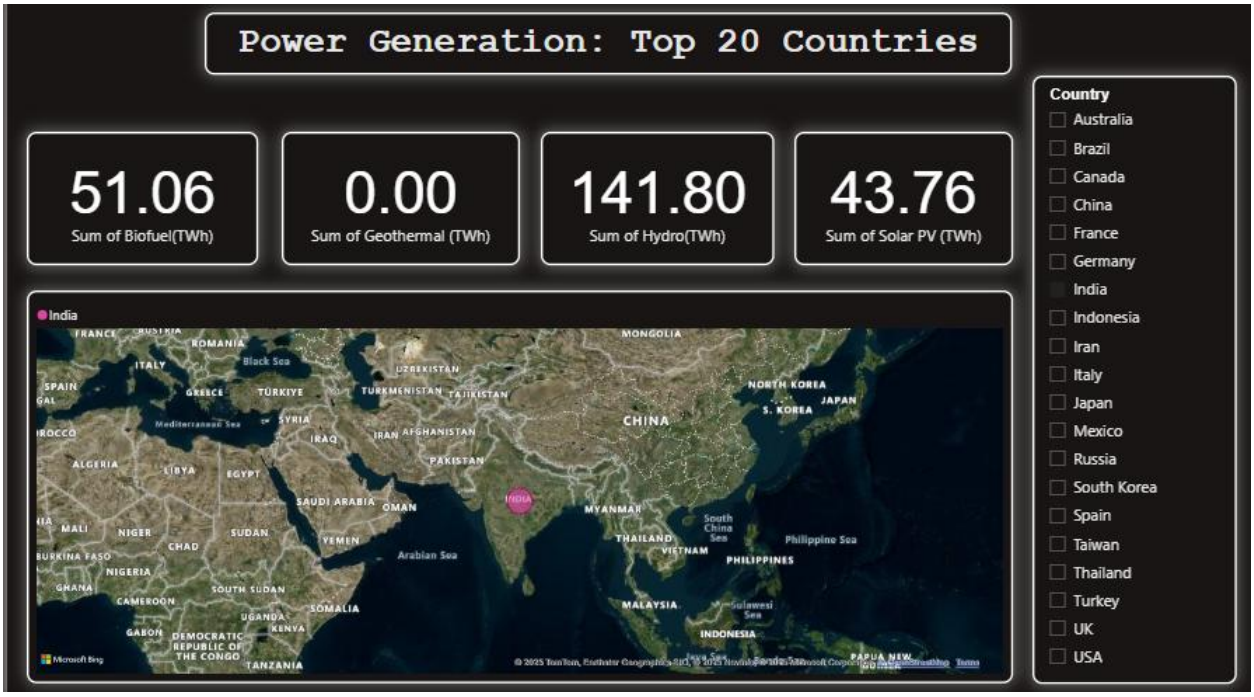
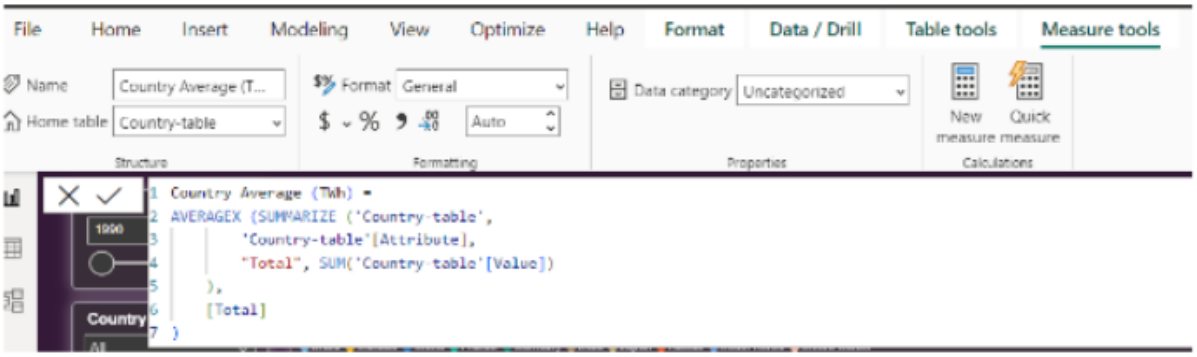
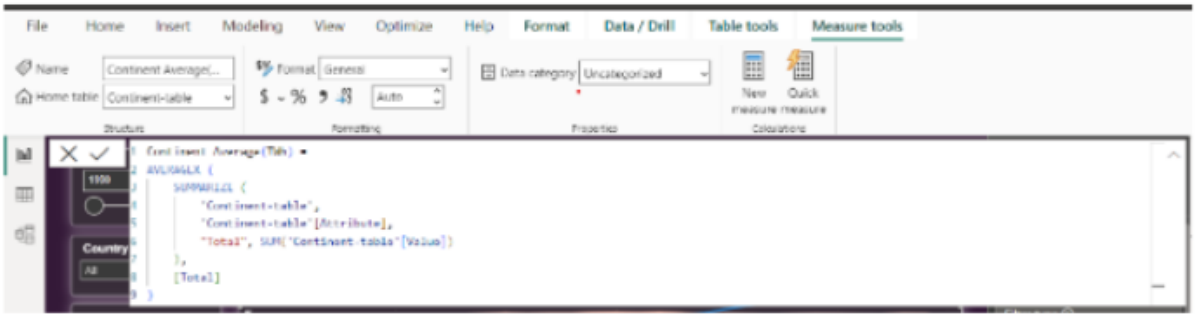


7.2 Number of Calculation Fields





7.3 Number of 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, Biofuel, Hydro and Solar PV
10. BRICS, OECD, and CIS Comparison
11. Report Narrative
12. Energy Consumption in African countries

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8. Conclusion/Observation

The Power BI-driven analysis of global energy trends has revealed several insightful patterns and observations regarding the evolution of energy consumption and generation across the world. These conclusions are based on historical data visualization, regional comparisons, and source-wise energy profiling.

Key Observations:

1. **Rising Global Energy Consumption**
   - Global energy consumption has been consistently increasing, particularly in fast-developing regions such as **Asia** and **Africa**.
   - **China** and **India** have emerged as two of the largest consumers of energy in the last two decades.
2. **Dominance of Non-Renewables (Still)**
   - Despite global efforts to transition to clean energy, **non-renewable sources** such as coal and natural gas continue to dominate total power generation globally.
   - **Coal** remains the leading energy source in many industrialized and emerging economies.
3. **Significant Growth in Renewable Energy (Post-2000)**
   - Renewable energy, especially **solar**, **wind**, and **hydro**, has seen remarkable growth since the year 2000.
   - Developed regions like **Europe** and certain **OECD countries** have increased their renewable energy generation substantially.
4. **Geographical Disparity in Energy Generation and Usage**
   - **Africa**, though rich in renewable resources, still lags in total energy generation due to infrastructure and investment challenges.

   - The **BRICS** countries have diverse energy portfolios, with Brazil leading in renewables and Russia dominating in non-renewables.
5. **Statistical Insights**
   - The **median and average consumption values** differ widely between continents, indicating unequal energy access.
   - **Variance and standard deviation** also highlight instability in growth rates among developing nations.
6. **Top Energy Contributors**
   - The **Top 20 countries** dominate global energy production and consumption, with the **USA, China, and Russia** being consistent leaders.
   - These countries have a major influence on global energy trends and carbon emissions.

The Power BI dashboard successfully delivers a **comprehensive, interactive, and data-driven narrative** on global energy dynamics. It highlights the **need for continued investment in renewable energy**, especially in underdeveloped regions, while also tracking the **uneven distribution and dependency** on fossil fuels across nations.

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9. Future Scope

This Power BI project provides a solid base for analyzing global energy trends. In future, the following enhancements can be made:

- **Live Data Integration**: Use APIs for real-time energy updates.
- **Forecasting**: Add predictive models to project future energy trends.
- **Regional Drill-Downs**: Create detailed dashboards for countries and regions.
- **Environmental Metrics**: Include CO_2 emissions and sustainability indicators.
- **Sector-wise Analysis**: Break down consumption by sectors like transport or industry.
- **Policy & Investment Data**: Add insights on energy policies and financial flows.
- **Mobile & Web Sharing**: Optimize dashboard for mobile and website embedding.
- **Multilingual Support**: Translate visuals for global accessibility.

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10. Appendix

10.1 Source Code

All development was done using Power BI Desktop. The .pbix file includes all DAX measures, calculated columns, and visuals used in the project.

10.2 GitHub & Project Demo Link

- GitHub Repository: https://github.com/RishabhBhatt28/Global-Energy-Trends
- Video Demonstration: https://drive.google.com/file/d/1RHQdrS3TjPJLAZKJ-jxkVspOT8an78te/view?usp=sharing