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

Team Details:

Team ID : LTVIP2025TMID19933

Team Leader : Hemanth Sai Madala(21481A5473)

Mail id: madalahemanthsai@gmail.com

Team member : Lakamsani Nikhil(21481A5470)

Mail id: nikhillakamsani@gmail.com

Team member : Venkat Raman Morla(21481A5488)

Mail id: venkataramanmorla@gmail.com

Team member : Aarathi Nagavalli Sangireddy(22485A5411)

Mail id: s.aarathi911@gmail.com

Technologies used:

Excel/CSV – Used as the dataset source.

Power Query – For data cleaning and transformation.

DAX (Data Analysis Expressions) – For creating calculated measures and

aggregations.

Power BI – For data visualization and dashboard creation.

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.

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:

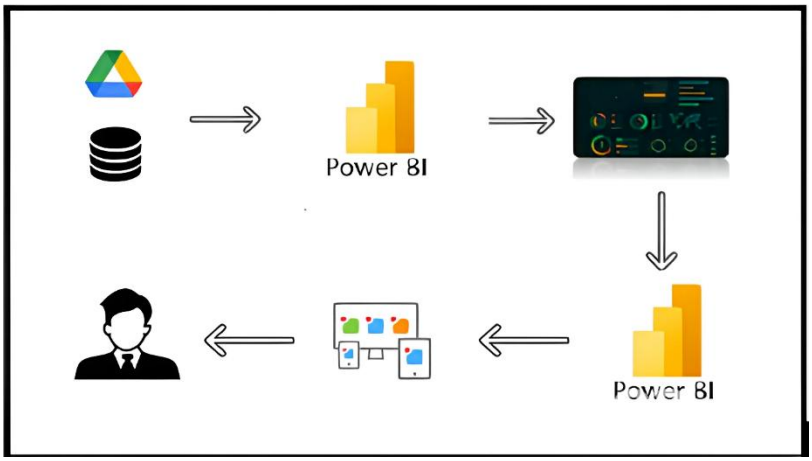
Industrial Energy Management in Manufacturing Plants: A large manufacturing plant recognizes the importance of optimizing energy usage to enhance its sustainability and cost-effectiveness. Leveraging data analysis techniques, the plant implements an advanced energy management system that monitors energy 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.

Technical Architecture :



Project Flow

To accomplish this, we have to complete all the activities listed below,

- Data Collection
- Collect the dataset,
- Connect Data with Power BI
- Data Preparation
- Prepare the Data for Visualization
- Data Visualizations
- Visualizations
- Dashboard
- Responsive and Design of Dashboard
- Report
- Report Creation
- Performance Testing
- Utilization of Data Filters
- No. of Calculation fields
- No. of Visualizations/Graphs
- Project Demonstration & Documentation

• Record explanation Video for project end to end solution

• Project Documentation-Step by step project development procedure

Milestone 1: Data Collection & Extraction from Database Data collection is the process of gathering and measuring information on variables of interest in a systematic manner to answer research questions, test hypotheses, and evaluate outcomes. This enables insights to be generated from the data.

Activity 1: Collect the dataset

Please use the link to download the dataset: Link

Activity 1.1: Understand the data The dataset contains all the meta-information regarding the columns described in the CSV files. We have provided a CSV file:

1. Energy_Consumption_Production

The dataset represents energy consumption and production across various sectors:

- Entity: Represents the country or region where the energy data is recorded.
- Code: A unique identifier or code for each entity (country or region).
- Year: The specific year for which the data is recorded, ranging from 1961 to 2023.
- Solar_Power_Generation (MW): The total annual solar energy production measured in megawatts.
- Wind_Power_Generation (MW): The total annual wind energy production measured in megawatts.
- Hydropower_Generation (MW): The total annual hydropower energy production measured in megawatts.
- Fossil_Fuel_Consumption (MWh): The total annual fossil fuel-based energy consumption.
- Energy_Usage_by_Sector: Energy consumption categorized by sectors (Residential, Industrial, Commercial, Transportation).
- Carbon_Emissions (tons): Total CO2 emissions generated from energy consumption.
- Renewable_Energy_Share (%): The percentage of total energy derived from renewable sources.

Activity 2: Connect Data with Power BI

1. Open Power BI Desktop.
2. Click on Home > Get Data.
3. Choose Excel/CSV/Database (depending on the dataset format).
4. Browse and select the dataset file.

5. Click Load/Transform to import the data into Power BI for further processing.

Milestone 2: Data Preparation

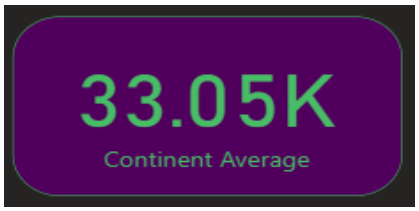
1. Data Cleaning:
    - Handling missing values: Fill gaps using interpolation or impute missing data.
    - Removing duplicates: Ensure data integrity by eliminating redundant records.
    - Standardizing units: Convert all measurements (MW, MWh, tons) into consistent units.
    - Fixing inconsistencies: Resolve formatting issues like date formats and text variations.
2. Data Transformation:
    - Merging multiple datasets: Combine data from different sources using joins and append queries.
    - Creating calculated columns: Compute energy efficiency metrics, renewable energy adoption rates, and per capita energy consumption.
    - Aggregating data: Summarize data at global, regional, and country levels.
    - Applying time-series transformations: Ensure data is structured for trend analysis.
3. Data Modeling in Power BI:
    - Creating relationships between tables using One-to-Many relationships (e.g., linking country codes to energy production data).
    - Building a Star Schema with Fact Tables (energy production, consumption, emissions) and Dimension Tables (countries, years, energy sources).
    - Using DAX (Data Analysis Expressions) to create measures for energy efficiency, carbon footprint reduction, and predictive analytics.
4. Data Visualization in Power BI:
    - Time-Series Analysis: Line charts showing energy consumption and production trends over decades.
    - Geospatial Analysis: World maps highlighting energy consumption and renewable energy adoption.
    - Comparative Analysis: Bar charts for country-wise comparisons.
    - Correlations: Scatter plots to analyze the relationship between energy consumption and CO2 emissions.
    - Forecasting Models: Predictive analytics using AI-powered features in Power BI.
5. Data Validation and Quality Assurance:
    - Cross-checking with official reports to verify accuracy.

- Ensuring data consistency across all visualizations.
- Implementing Row-Level Security (RLS) to restrict access to specific country data if needed.

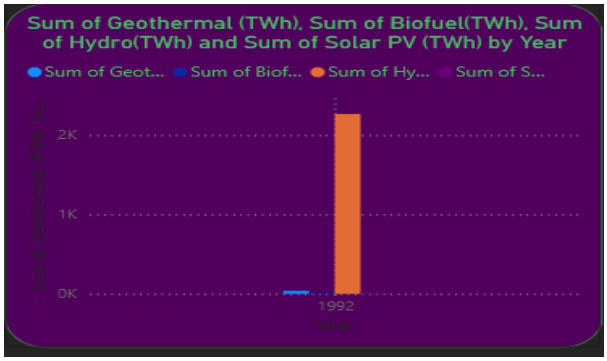
Milestone 3: Data Visualization Activity 1: No of Unique Visualizations Various types of visualizations help analyze energy production trends and sustainability impacts.

Visualizations Used:

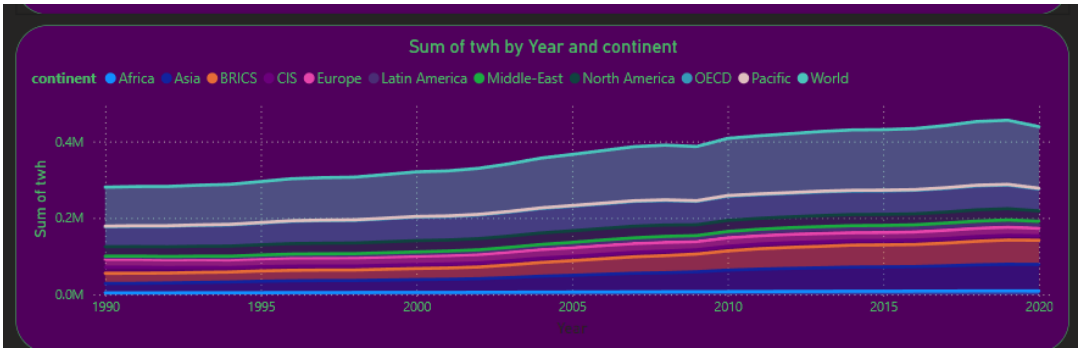
- Card: Displays key performance indicators (KPIs) such as total renewable energy share.



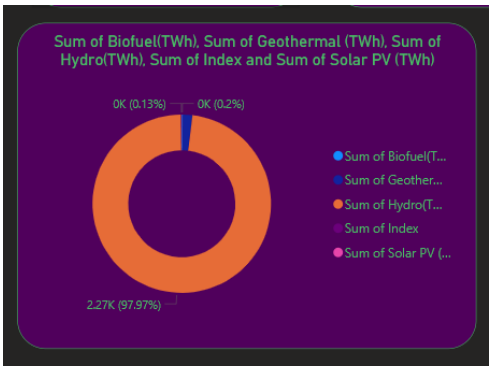
- Gauge: Shows progress toward renewable energy targets.
- Stacked Column Chart: Compares energy consumption by sector.



- Ribbon Chart: Tracks rank changes in renewable energy adoption over time.
- Stacked Area Chart: Visualizes energy production contributions by source.



- Doughnut Chart: Displays energy consumption proportions by sector.



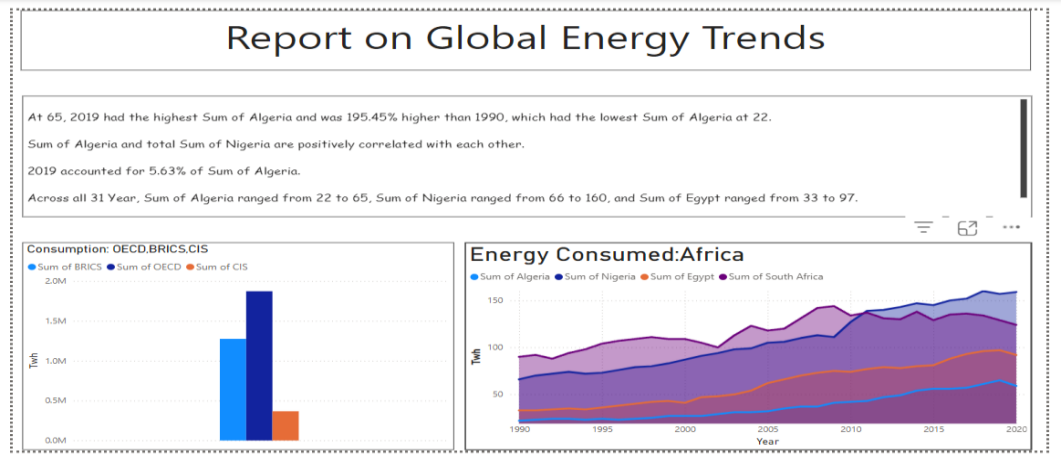
Milestone 5: Dashboard A well-designed Power BI dashboard for Global Energy Trends and Sustainability should be responsive, visually appealing, and user-friendly.

Key aspects:

- Adaptive Grid Design: Arrange visuals in a structured layout.
- Dynamic Resizing: Use relative sizing for adaptability.
- Mobile-Friendly Design: Optimize dashboard for Power BI Mobile View.
- Page Navigation: Implement buttons, bookmarks, and drill-through pages.

Milestone 6: Report

- Created a comprehensive Power BI report summarizing key insights.



- The report includes:
  - Growth patterns in renewable energy adoption.
  - Correlation analysis between energy consumption and CO2 emissions.

- Data-driven insights for better energy management decisions.

Milestone 7: Performance Testing Activity 1: Utilization of Data Filters

- Optimized dataset loading for better performance.
- Limited complex DAX calculations to maintain efficiency.

Activity 2: Number of Visualizations/Graphs

1. Renewable Energy Share by Country – Bar Chart
2. Energy Consumption Trends – Line Chart
3. CO2 Emissions vs. Energy Consumption – Scatter Plot
4. Renewable vs. Non-Renewable Energy Use – Stacked Bar Chart
5. Energy Efficiency Metrics by Sector – Treemap
6. Solar & Wind Power Growth – Area Chart
7. Fossil Fuel Dependence by Region – Bubble Chart

Milestone 8: Project Demonstration & Documentation Activity 1: Record explanation video for project end-to-end solution Creating a recorded explanation video to ensure clarity in project implementation.

Explanation video: Link

Activity 2: Project Documentation – Step-by-step project development procedure

1. Imported Dataset into Power BI.
2. Performed Data Cleaning & Transformation using Power Query.
3. Created New Columns & Measures for deeper analysis.
4. Designed Data Visualizations & Dashboard.
5. Developed & Published Power BI Report.
6. Conducted Performance Testing to optimize efficiency.
7. Finalized Documentation for better project presentation.