Design Report

Global Energy Consumption: A Comparative and Predictive Analysis

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1. Introduction

Energy consumption is one of the most critical indicators of global development. As populations expand and industrial activity increases, understanding historical and contemporary energy patterns becomes essential for sustainable planning, infrastructure development, and climate policy formulation.

This project explores global energy consumption trends from 1800 to 2024 using international datasets, and presents findings through an interactive, user-friendly Power BI dashboard. The design integrates visual storytelling, comparative analytics, and interactive exploration capability to help users gain insight into global energy usage disparities, transitions in fuel types, and long-term projections.

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2. Problem Statement

Global energy demand is increasing, yet consumption patterns differ sharply across countries and continents. Fossil fuels continue to dominate despite rapid renewable growth. Policymakers, researchers, and sustainability planners require tools to:

- Compare per-capita energy consumption across regions
- Track fuel-type transitions over time
- Understand inequality in consumption
- Project potential future trends

Traditional static charts cannot fully capture these relationships. Therefore, an interactive visualization dashboard is needed to help stakeholders explore energy trends dynamically.

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3. Objectives

The design of this project was guided by the following objectives:

1. **Analyse long-term trends** in global energy consumption from 1800–2024.
2. **Compare developed vs. developing nations** based on per-capita energy usage.

3. **Examine shifts in global fuel types**, including fossil fuels, nuclear, and renewables.
4. **Visualize continental and country-level contributions** to global energy use.
5. **Enable interactive exploration** to support year-based filtering and regional comparisons.
6. **Design a visually clear, informative Power BI dashboard** that is intuitive for both technical and non-technical audiences.

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4. Dataset Description

We used global energy datasets compiled from international sources such as:

- Global Energy Historical Database
- International Energy Agency (IEA)
- United Nations population projections
- Country-level energy indicators

Key dataset features:

- **Years:** 1800–2024
- **Countries:** 200+
- **Variables:**
  - Primary energy consumption per capita
  - Total TWh by energy source
  - Solar, wind, hydropower, nuclear, gas, oil, coal, and biofuels
  - Population and geographic region mapping

Data Pre-processing

- Handling missing values
- Standardizing units (e.g., TWh, kWh/person)
- Grouping countries by continent
- Mapping country codes for geographic visuals
- Creating calculated fields for fossil vs renewable categories
- Reducing noise in early years with sparse data

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5. Methodology

5.1 Data Cleaning & Transformation

We performed data cleansing using Python and Power Query:

- Removed corrupted or incomplete rows
- Normalized column names
- Joined multiple datasets using country and year keys

- Created new attributes (e.g., “Total Renewable,” “Total Fossil”)
- Aggregated continental values

5.2 Dashboard Design Process

The dashboard was designed using an iterative approach:

1. **Requirement gathering**
2. **Wireframe sketches**
3. **Visual selection** (line charts, bar charts, maps, pie charts)
4. **Interactivity planning** (filters, slicers, tooltips)
5. **Color theme selection**
6. **User testing & refinement**

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6. Dashboard Design

The dashboard contains **two fully interactive pages**, optimized for clarity, comparison, and storytelling.

Page 1: Global Trends & Country-Level Comparison

Features

1. **Global Energy Over Time (1800–2024)**
   A multi-line chart showing historical trends of all major energy types.
2. **Country-Level Energy Consumption Map**
   A world map displaying per-capita consumption for each country with color gradation.
3. **Top Energy Consumers (Bar Chart)**
   High-income countries such as Qatar, the USA, and Iceland appear at the top.
4. **Lowest Energy Consumers (Bar Chart)**
   Several African countries appear with minimal consumption per capita.

Design Rationale

- The map provides intuitive geographic comparison.
- Bar charts highlight inequality levels clearly.
- Line charts illustrate long-term energy transition patterns.

Page 2: Global Energy Mix & Source Breakdown

Features

1. **Solar and Wind Growth Over Time**
   Focused line chart emphasizing exponential growth post-2000.
2. **Fossil vs Renewable Energy Comparison**
   Overlaid area chart visualizing global dependence on fossil fuels.
3. **Total Global Energy Pie Chart**
   Displays the full world energy mix for a selected year.
4. **Year Slicer (1800–2024)**
   Users can explore any year and instantly update all visuals.

Design Rationale

- A pie chart communicates source contribution clearly.
- A slicer encourages user exploration and avoids static interpretation.
- Comparing fossil vs renewable sources supports sustainability insights.

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7. Interactivity & User Experience

The design emphasizes **high interactivity**:

- **Year filters** for dynamic historical exploration
- **Hover-based tooltips** showing detailed numeric values
- **Cross-highlighting** between charts
- **Scrollable bar charts** for large datasets
- **Continent and country comparisons** for user flexibility

This enhances usability for researchers, educators, and policymakers.

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8. Results & Key Findings

Based on our dashboard analysis:

1. **Global energy usage has increased exponentially**, especially after 1950.
2. **Fossil fuels still dominate**, but renewables show rapid post-2000 growth.
3. **Developed countries consume up to 20× more energy per capita** than developing nations.

4. **Asia is the largest contributor to global growth**, driven by population and industrialization.
5. **Low-income nations remain energy-poor**, highlighting global inequality.
6. **Future projections** show major shifts toward solar and wind by 2100.

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9. Design Evaluation

Strengths

- Highly interactive
- Clean layout and intuitive navigation
- Effective use of Power BI visuals
- Transparent data processing
- Strong comparative storytelling

Limitations

- Some years before 1900 have sparse data
- Population projections beyond 2100 were not included
- Some smaller countries may have incomplete historical records

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10. Conclusion

The dashboard successfully meets its goal: providing an interactive, analytical view of global energy patterns over more than two centuries. It reveals major trends, sharp inequalities, and rapid shifts toward renewable sources.

The design supports policymakers, educators, and researchers who seek to understand global energy transitions. With future integration of real-time data and more advanced forecasting models, this tool can evolve into a broader sustainability analytics platform.

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11. Future Enhancements

- Add machine learning models for predictive forecasting
- Build continent-specific dashboards
- Integrate GDP and CO_2 emissions for deeper insight
- Create mobile-optimized versions
- Add scenario-based projections (policy, technology, climate events)

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12. References

Data sources include international energy repositories, UN population projections, and global historical energy datasets.

Transparency Note: Parts of this report were developed with the assistance of ChatGPT to improve clarity and structure, basically to improve readability.