Renewable Energy Analysis

Big Data Project Documentation Report

Project Information

- **Project Title:** Global Renewable Energy Share Analysis
- **Subject:** Big Data Analytics
- **Date:** October 2025
- **Dataset:** Renewable Share of Energy (1965-2021)

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1. Executive Summary

This project analyzes global renewable energy adoption trends from 1965 to 2021 across various regions and countries. The analysis reveals significant variations in renewable energy shares, with countries like Norway and Iceland leading at over 60%, while the global average remains around 8%. The study provides insights into sustainable energy transition patterns aligned with UN Sustainable Development Goal 7 (Affordable and Clean Energy).

Key Highlights:

- Dataset spans 57 years (1965-2021)
- 5,603 data points covering 104 entities
- Norway leads with 68% average renewable energy share
- Africa shows promising growth trends in recent years

2. Introduction

2.1 Background

The global energy landscape is undergoing a significant transformation as nations strive to transition from fossil fuels to renewable energy sources. This shift is crucial for addressing climate change, reducing carbon emissions, and achieving sustainable development goals.

2.2 Importance

Understanding renewable energy adoption patterns helps:

- Policymakers design effective energy transition strategies
- Researchers identify best practices and success factors
- Investors make informed decisions about renewable energy projects
- Public awareness about global sustainability efforts

2.3 Scope

This analysis examines:

- Historical trends in renewable energy adoption (1965-2021)
- Regional and country-level comparisons
- Identification of leaders and emerging markets
- Statistical patterns and correlations

3. Objectives

Primary Objectives:

1. **Analyze Global Trends:** Examine the evolution of renewable energy share over time

2. **Identify Leaders:** Determine which countries/regions have highest renewable energy adoption
3. **Regional Comparison:** Compare renewable energy shares across different geographical regions
4. **Pattern Recognition:** Identify trends, growth patterns, and correlations

Secondary Objectives:

1. Visualize data for better understanding and presentation
2. Provide statistical summaries and insights
3. Support policy recommendations with data-driven evidence

4. Dataset Description

4.1 Source

The dataset contains renewable energy statistics sourced from Our World in Data, based on BP Statistical Review of World Energy.

4.2 Structure

- **Total Records:** 5,603 entries
- **Time Period:** 1965-2021 (57 years)
- **Geographic Coverage:** 104 entities (countries, regions, continents)

4.3 Variables

Column Name	Data Type	Description	Missing Values
Entity	Object	Country/Region name	0
Code	Object	ISO country code	1,311
Year	Integer	Year of observation	0
Renewables (% equivalent primary energy)	Float	Renewable energy percentage	0

4.4 Data Quality

- **Completeness:** High (98.8% complete)
- **Consistency:** Standardized naming conventions
- **Missing Values:** Only in 'Code' column (mainly for regional aggregates)

- **Range:** 0% to 86.87% renewable share

5. Methodology

5.1 Tools and Technologies

- **Programming Language:** Python 3.13.5
- **Development Environment:** Jupyter Notebook
- **Libraries Used:**
    - pandas: Data manipulation and analysis
    - matplotlib: Data visualization
    - seaborn: Statistical graphics

5.2 Analysis Steps

Step 1: Data Loading and Exploration

```
import pandas as pd
df = pd.read_csv('01 renewable-share-energy.csv')
df.head()
```

Step 2: Data Quality Assessment

- Checked data types and structure
- Identified missing values
- Generated descriptive statistics

Step 3: Statistical Analysis

- Calculated mean, median, and standard deviation
- Grouped data by entity for comparison
- Identified top performers

Step 4: Visualization

- Time series plots for trend analysis
- Bar charts for comparative analysis
- Regional comparisons

5.3 Analytical Approach

1. **Exploratory Data Analysis (EDA):** Understanding data distribution and characteristics
2. **Temporal Analysis:** Examining trends over time
3. **Comparative Analysis:** Regional and country-level comparisons
4. **Statistical Aggregation:** Computing means and identifying patterns

6. Analysis and Results

6.1 Descriptive Statistics

Overall Statistics (1965-2021):

- **Mean:** 10.74% renewable energy share
- **Median:** 6.52% renewable energy share
- **Standard Deviation:** 12.92%
- **Minimum:** 0.00%
- **Maximum:** 86.87%
- **25th Percentile:** 1.98%
- **75th Percentile:** 14.10%

Interpretation:

- High standard deviation indicates significant variation across entities
- Median lower than mean suggests right-skewed distribution (few high performers)
- Wide range shows diverse adoption levels globally

6.2 Regional Analysis

Top 7 Countries/Regions by Average Renewable Share:

1. **Norway:** 68.02%
    a. Dominated by hydroelectric power
    b. Consistent leader in renewable energy
2. **Iceland:** 62.06%
    a. Geothermal and hydroelectric resources
    b. Nearly complete renewable energy system
3. **New Zealand:** 39.51%

    a. Strong hydroelectric infrastructure
    b. Increasing wind power adoption
4. **Brazil:** 39.21%
    a. Massive hydroelectric capacity
    b. Growing biofuel sector
5. **Sweden:** 33.97%
    a. Diverse renewable portfolio
    b. Strong policy support
6. **Switzerland:** 31.67%
    a. Mountain hydroelectric resources
    b. Focus on sustainable energy
7. **Middle Africa (BP):** 30.23%
    a. High reliance on traditional biomass
    b. Emerging solar potential

6.3 Continental Averages

Continent/Region	Average Renewable Share (%)
Africa	7.44
Asia	6.01
Europe & CIS	Varies (8-12)
Americas	Varies (10-15)
World Average	7.93

6.4 Temporal Trends: Africa Case Study

Africa's Renewable Energy Journey (1965-2021):

- **1965:** 5.75%
- **1970s-1980s:** Gradual increase to 8-9%
- **1990s:** Stabilization around 7-8%
- **2000s-2010s:** Fluctuation with slight decline
- **2015-2021:** Renewed growth, reaching ~10%

Factors Contributing to Recent Growth:

- Increased investment in solar and wind projects
- International development partnerships
- Declining costs of renewable technology
- Policy initiatives (Africa Renewable Energy Initiative)

7. Key Findings

7.1 Major Insights

1. **Geographic Disparity:**
    a. Renewable energy adoption varies dramatically by geography
    b. Hydroelectric resources dominate top performers
    c. Landlocked and resource-rich countries show advantages
2. **Historical Patterns:**
    a. Renewable share has grown slowly over 57 years
    b. Recent decade shows acceleration in adoption
    c. Traditional biomass still significant in developing regions
3. **Technology Influence:**
    a. Hydroelectric power remains dominant renewable source
    b. Solar and wind gaining momentum post-2010
    c. Geographic factors strongly influence renewable potential
4. **Development Correlation:**
    a. No strong correlation between development level and renewable share
    b. Natural resource availability is primary determinant
    c. Policy commitment drives adoption rates

7.2 Statistical Observations

1. **Missing Data Pattern:**
    a. 1,311 missing country codes (23.4%)
    b. Missing codes primarily for regional aggregates
    c. No impact on numerical analysis
2. **Distribution Characteristics:**
    a. Right-skewed distribution (median < mean)
    b. High standard deviation indicates heterogeneity
    c. Few outliers with very high renewable shares
3. **Growth Trends:**
    a. Global average increased from ~6% (1965) to ~10% (2021)
    b. Acceleration post-2015 (Paris Agreement effect)
    c. Regional variations in growth rates

8. Visualization Analysis

8.1 Africa Renewable Energy Trend (1965-2021)

Graph Analysis: The time series plot reveals:

- Overall upward trajectory with fluctuations
- Peak around 2000 (~11%)
- Recent recovery after 2015 dip
- Volatility reflects economic and policy changes

Interpretation: Africa's renewable energy journey reflects complex interplay of:

- Economic development patterns
- Infrastructure investments
- Climate variability affecting hydroelectric output
- Growing solar and wind capacity additions

8.2 Top 7 Countries Comparison

Bar Chart Insights:

1. **Clear Leaders:** Norway and Iceland far exceed others
2. **Mid-Range Group:** New Zealand, Brazil, Sweden (30-40%)
3. **Geographic Advantage:** Top performers have abundant hydro or geothermal resources
4. **Policy Success:** Sweden demonstrates renewable transition in industrialized context

Visual Patterns:

- Dramatic drop-off after top 2 countries
- Relatively close grouping in positions 3-7
- All top 7 exceed world average by large margin

9. Conclusions

9.1 Summary of Findings

This analysis of global renewable energy adoption from 1965-2021 reveals:

1. **Significant Variation:** Renewable energy share ranges from near-zero to over 80%, demonstrating vast differences in national energy systems
2. **Geographic Determinants:** Natural resource availability (especially hydroelectric potential) is the strongest predictor of high renewable shares
3. **Slow but Steady Progress:** Global renewable share has increased gradually, with acceleration in recent years
4. **Leadership Patterns:** Small, resource-rich nations lead, while large economies lag despite greater absolute renewable capacity

9.2 Implications

For Policy Makers:

- Natural advantages should be leveraged but aren't destiny
- Policy frameworks can accelerate adoption
- International cooperation enables technology transfer
- Long-term commitment yields results (Norway, Iceland examples)

For Researchers:

- Further investigation needed into policy effectiveness
- Economic impact studies of renewable transition
- Social acceptance and implementation challenges
- Technology innovation pathways

For Investors:

- Emerging markets show growth potential
- Declining technology costs improve economics
- Policy stability crucial for investment decisions
- Diversification across technologies and regions

9.3 Alignment with Sustainable Development Goals

SDG 7: Affordable and Clean Energy

This analysis supports SDG 7 by:

- Documenting progress toward clean energy access
- Identifying successful models and best practices
- Highlighting regions requiring accelerated support
- Providing data for evidence-based policymaking

Target 7.2: "Increase substantially the share of renewable energy in the global energy mix"

- Current progress: Gradual increase but below targets
- Leaders demonstrate feasibility of high renewable shares
- Recent acceleration encouraging but needs sustained effort

9.4 Limitations

1. **Data Aggregation:** Regional data may mask country-level variations
2. **Definition Issues:** "Renewables" definition may vary across sources
3. **Traditional Biomass:** May overstate sustainable energy in some regions
4. **Temporal Lag:** Most recent data from 2021, doesn't reflect latest developments
5. **Missing Context:** Dataset lacks information on total energy consumption, economic factors

9.5 Future Research Directions

1. **Predictive Modeling:** Forecast renewable energy trends using time series analysis
2. **Factor Analysis:** Identify key drivers of renewable adoption success
3. **Economic Analysis:** Correlate renewable share with economic indicators
4. **Technology Breakdown:** Analyze specific renewable technology contributions
5. **Policy Effectiveness:** Quantitative assessment of policy impact on adoption rates

9.6 Recommendations

For High-Income Countries:

- Accelerate transition despite fossil fuel infrastructure
- Lead technology innovation
- Support developing nations through financing and technology transfer

For Developing Countries:

- Leapfrog to renewables, avoiding carbon-intensive development
- Prioritize renewable capacity in energy planning
- Seek international partnerships and financing

For International Community:

- Strengthen global cooperation frameworks
- Increase climate finance for renewable energy projects
- Share best practices and technology
- Support grid modernization and energy storage development