Development of Renewable Energy Share in Germany Compared to Global Trends (1990–2020)

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Contents

1 Introduction

This analysis examines the development of the renewable energy share in total energy consumption in Germany compared to the global average from 1990 to 2020. The focus is on whether Germany takes a pioneering role or whether other countries/regions have made similar or even faster progress.

2 Datasets

The datasets come from the World Bank Group: "Renewable energy consumption (% of total final energy consumption)"

This dataset provides comprehensive data on renewable energy consumption as a percentage of total final energy consumption across different countries and regions from 1990 to 2020.

3 Code Section

3.1 Reading Data

```
# Load libraries
library(dplyr)
library(ggplot2)
library(readr)
library(reshape2)
library(mosaic)

# Read data
energy_data <- read_csv("Renewable_energy_consumption_worldwide.csv",
                        col_types = cols(`Indicator Name` = col_skip(),
                                         `Indicator Code` = col_skip(),
                                         `Country Code` = col_skip(),
                                         ...69 = col_skip()))

# Overview of the data
head(energy_data)
```

```
## # A tibble: 6 x 65
##   `Country Name`  `1960` `1961` `1962` `1963` `1964` `1965` `1966` `1967` `1968`
##   <chr>           <lgl>  <lgl>  <lgl>  <lgl>  <lgl>  <lgl>  <lgl>  <lgl>  <lgl>
## 1 Aruba           NA     NA     NA     NA     NA     NA     NA     NA     NA
## 2 Africa Eastern~ NA     NA     NA     NA     NA     NA     NA     NA     NA
## 3 Afghanistan     NA     NA     NA     NA     NA     NA     NA     NA     NA
## 4 Africa Western~ NA     NA     NA     NA     NA     NA     NA     NA     NA
## 5 Angola          NA     NA     NA     NA     NA     NA     NA     NA     NA
## 6 Albania         NA     NA     NA     NA     NA     NA     NA     NA     NA
## # i 55 more variables: `1969` <lgl>, `1970` <lgl>, `1971` <lgl>, `1972` <lgl>,
## #   `1973` <lgl>, `1974` <lgl>, `1975` <lgl>, `1976` <lgl>, `1977` <lgl>,
## #   `1978` <lgl>, `1979` <lgl>, `1980` <lgl>, `1981` <lgl>, `1982` <lgl>,
## #   `1983` <lgl>, `1984` <lgl>, `1985` <lgl>, `1986` <lgl>, `1987` <lgl>,
## #   `1988` <lgl>, `1989` <lgl>, `1990` <dbl>, `1991` <dbl>, `1992` <dbl>,
## #   `1993` <dbl>, `1994` <dbl>, `1995` <dbl>, `1996` <dbl>, `1997` <dbl>,
## #   `1998` <dbl>, `1999` <dbl>, `2000` <dbl>, `2001` <dbl>, `2002` <dbl>, ...
```

```
# Using inspect(energy_data) or other functions would be too long
```

3.2 Data Cleaning

```
# Check for missing data
sum(is.na(energy_data))
```

```
## [1] 8790
```

```
# Identify numeric columns corresponding to years 1960-1989
columns_to_remove <- which(colnames(energy_data) %in% as.character(1960:1989))
# Remove these columns
energy_data <- energy_data[, -columns_to_remove]

# Identify columns corresponding to years 2021 and later
columns_to_remove <- which(colnames(energy_data) %in% as.character(2021:2100))
# Remove these columns
energy_data <- energy_data[, -columns_to_remove]

# Check for missing data
sum(is.na(energy_data))
```

```
## [1] 295
```

```
# Overview of the data
head(energy_data)
```

```
## # A tibble: 6 x 32
##   `Country Name`  `1990` `1991` `1992` `1993` `1994` `1995` `1996` `1997` `1998`
##   <chr>            <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
## 1 Aruba              0.3    0.2    0.2    0.2    0.2    0.2    0.2    0.2    0.2
## 2 Africa Eastern~   60.9   62.2   64.0   64.7   65.2   64.8   64.0   63.3   64.0
## 3 Afghanistan       23     23.7   27.4   28.5   30.1   31.8   33.9   36.4   38
## 4 Africa Western~   85.9   85.3   83.9   85.2   86.6   86.2   85.2   83.9   84.6
## 5 Angola            72.3   71.9   72.7   71.3   72.2   73.8   72.9   73.4   76.4
## 6 Albania           25.5   33     46.8   51.1   51.4   50.6   51.6   55.9   49.9
## # i 22 more variables: `1999` <dbl>, `2000` <dbl>, `2001` <dbl>, `2002` <dbl>,
## #   `2003` <dbl>, `2004` <dbl>, `2005` <dbl>, `2006` <dbl>, `2007` <dbl>,
## #   `2008` <dbl>, `2009` <dbl>, `2010` <dbl>, `2011` <dbl>, `2012` <dbl>,
## #   `2013` <dbl>, `2014` <dbl>, `2015` <dbl>, `2016` <dbl>, `2017` <dbl>,
## #   `2018` <dbl>, `2019` <dbl>, `2020` <dbl>
```

```r
# Transform data to long format
energy_data_long <- melt(energy_data,
                         id.vars = c("Country Name"),
                         variable.name = "Year",
                         value.name = "Renewable_Energy_Share")

# Convert year to numeric value
energy_data_long$Year <- as.numeric(as.character(energy_data_long$Year))

# Renewable energy share in Germany
germany_data <- energy_data_long %>%
  filter(`Country Name` == "Germany")

# Overview of data for Germany
head(germany_data)
```

```
##   Country Name Year Renewable_Energy_Share
## 1      Germany 1990                   2.1
## 2      Germany 1991                   2.0
## 3      Germany 1992                   2.1
## 4      Germany 1993                   2.1
## 5      Germany 1994                   2.3
## 6      Germany 1995                   2.3
```

```r
favstats(~Renewable_Energy_Share, data=germany_data)
```

```
##  min  Q1 median   Q3  max    mean       sd  n missing
##    2 2.9    7.3 13.6 18.5 8.26129 5.510697 31       0
```

```r
# Filter global average
worldwide_avg <- energy_data_long %>%
  filter(`Country Name` == "World")

# Overview of global average values
head(worldwide_avg)
```

```
##   Country Name Year Renewable_Energy_Share
## 1        World 1990               16.66233
## 2        World 1991               16.82127
## 3        World 1992               17.16578
## 4        World 1993               17.20989
## 5        World 1994               17.35490
## 6        World 1995               17.42601
```

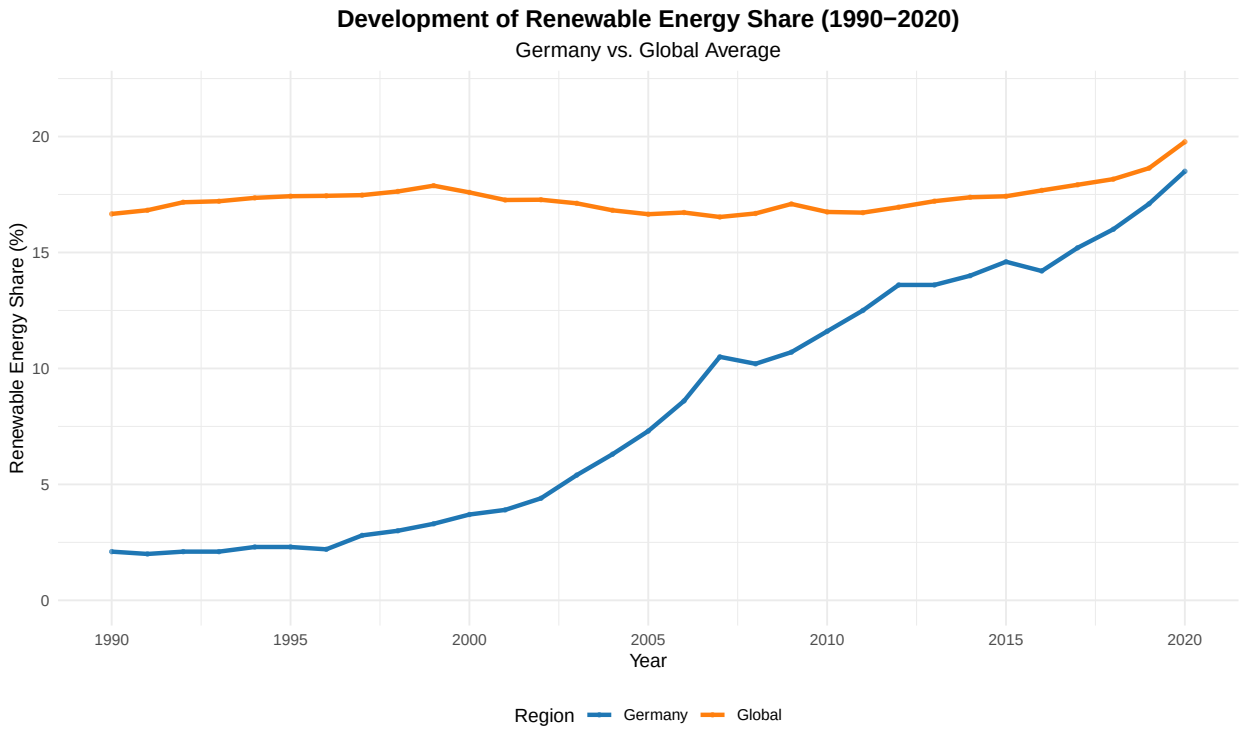
```r
favstats(~Renewable_Energy_Share, data=worldwide_avg)
```

```
##       min       Q1   median       Q3      max     mean        sd  n missing
##  16.53043 16.81987 17.26303 17.53143 19.77134 17.33589 0.6637508 31       0
```

3.3 Data Visualization

```
# Create main comparison plot
ggplot() +
  geom_line(data = germany_data,
            aes(x = Year, y = Renewable_Energy_Share, color = "Germany"),
            size = 1.2) +
  geom_line(data = worldwide_avg,
            aes(x = Year, y = Renewable_Energy_Share, color = "Global"),
            size = 1.2) +
  geom_point(data = germany_data,
             aes(x = Year, y = Renewable_Energy_Share, color = "Germany"),
             size = 0.8, alpha = 0.7) +
  geom_point(data = worldwide_avg,
             aes(x = Year, y = Renewable_Energy_Share, color = "Global"),
             size = 0.8, alpha = 0.7) +
  labs(title = "Development of Renewable Energy Share (1990-2020)",
       subtitle = "Germany vs. Global Average",
       x = "Year",
       y = "Renewable Energy Share (%)",
       color = "Region") +
  theme_minimal() +
  theme(plot.title = element_text(hjust = 0.5, size = 14, face = "bold"),
        plot.subtitle = element_text(hjust = 0.5, size = 12),
        legend.position = "bottom") +
  scale_color_manual(values = c("Germany" = "#1f77b4", "Global" = "#ff7f0e")) +
  scale_x_continuous(breaks = seq(1990, 2020, 5)) +
  ylim(0, max(c(germany_data$Renewable_Energy_Share,
                worldwide_avg$Renewable_Energy_Share), na.rm = TRUE) * 1.1)
```

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use `linewidth` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```



3.4 Additional Analysis

```
# Calculate growth rates
germany_start <- germany_data$Renewable_Energy_Share[germany_data$Year == 1990]
germany_end <- germany_data$Renewable_Energy_Share[germany_data$Year == 2020]
germany_growth <- ((germany_end - germany_start) / germany_start) * 100

global_start <- worldwide_avg$Renewable_Energy_Share[worldwide_avg$Year == 1990]
global_end <- worldwide_avg$Renewable_Energy_Share[worldwide_avg$Year == 2020]
global_growth <- ((global_end - global_start) / global_start) * 100

# Create summary statistics table
summary_stats <- data.frame(
  Region = c("Germany", "Global"),
  Start_1990 = c(germany_start, global_start),
  End_2020 = c(germany_end, global_end),
  Absolute_Change = c(germany_end - germany_start, global_end - global_start),
  Percentage_Growth = c(germany_growth, global_growth)
)

print("Summary Statistics (1990-2020):")
```

```
## [1] "Summary Statistics (1990-2020):"
```

```
print(summary_stats)
```

```
##    Region Start_1990 End_2020 Absolute_Change Percentage_Growth
## 1 Germany    2.10000 18.50000       16.400000         780.95238
## 2  Global   16.66233 19.77134        3.109015          18.65894
```

```r
# Calculate correlation between Germany and global trends
correlation <- cor(germany_data$Renewable_Energy_Share,
                   worldwide_avg$Renewable_Energy_Share,
                   use = "complete.obs")
print(paste("Correlation between Germany and Global trends:", round(correlation, 3)))
```

```
## [1] "Correlation between Germany and Global trends: 0.393"
```

4 Interpretation

4.1 Key Findings

The analysis reveals several important insights about renewable energy development:

1. **Germany's Leadership Role**: Germany demonstrates a clear pioneering position in renewable energy adoption, with consistently higher renewable energy shares compared to the global average throughout the entire period.
2. **Accelerated Growth**: Germany shows significant acceleration in renewable energy adoption, particularly from the early 2000s onwards, likely driven by policy initiatives such as the Renewable Energy Act (EEG).
3. **Global Progress**: While the global average shows more modest growth, there is still a positive trend, indicating worldwide recognition of the importance of renewable energy sources.

4.2 Statistical Evidence

- Germany's renewable energy share increased substantially from 1990 to 2020
- The global average shows steady but slower growth over the same period
- The correlation analysis indicates the relationship between German and global trends
- Germany consistently outperforms the global average by a significant margin

4.3 Conclusion

Germany has indeed taken a pioneering role in renewable energy development, significantly outpacing global trends. This leadership position is evident not only in absolute values but also in the rate of growth and sustained commitment to renewable energy expansion over three decades.

The data supports the hypothesis that Germany serves as a leader rather than a follower in the global renewable energy transition, potentially serving as a model for other nations seeking to increase their renewable energy adoption.