

## 1. Abstract

This study explores renewable energy trends and the role of the electricity sector in different regions. By focusing on East Asia & Pacific, Europe & Central Asia, and North America, it examines the growth of renewable energy production and its share of total energy supply. Additionally, the analysis investigates the relationship between GDP and hydroelectric energy usage and evaluates how nuclear energy consumption varies across income groups. The findings highlight regional differences in energy trends, with Europe & Central Asia experiencing the fastest growth in renewable energy. Wealthier nations tend to invest more heavily in hydroelectric and nuclear energy infrastructure, reflecting broader economic and policy influences.

## 2. Introduction

Energy consumption is a critical driver of economic growth and environmental sustainability. This report examines renewable energy production trends and electricity sector contributions, addressing several key questions:

1. How has renewable energy production evolved in different regions over time?
2. What percentage of total energy supply is derived from renewable sources?
3. Is there a relationship between a country's GDP and its use of hydroelectric power?
4. How does nuclear energy consumption vary across income groups?

By answering these questions, this report provides insights into how economic factors and policy initiatives shape global energy trends.

## 3. Methodology

### Part 1: Renewable Energy Trends by Region

Two datasets from the International Energy Agency were used:

- DP\_Live\_energy\_Renewable.csv — containing renewable energy production data.
- DP\_Live\_energy\_PrimaryEnergySupply.csv — showing total primary energy supply.

Each dataset was pre-processed by skipping header rows and renaming columns for clarity. Data was filtered to include only the following regions: *East Asia & Pacific*, *Europe & Central Asia*, and *North America*. These were chosen to represent a diverse mix of economic and policy backgrounds.

The datasets were then merged using three common columns: Country, Year, and Region. This merge allowed for a direct comparison of renewable energy production and total

energy supply in the same country and year. After merging, a new column was calculated, This column represents the percentage of total energy supply that comes from renewable sources for each data point. To observe trends over time, the data was grouped by region and year and the resulting data was visualized in two-line plots:

- Total renewable energy generation over time.
- Renewable energy as a percentage of total energy supply over time.

These visualizations were used to assess whether renewable energy use has increased over time and how it varies between regions.

## **Part 2: Electricity Sector Contributions**

The second part of the analysis used a World Bank dataset containing demographic and electricity sector data:

- API\_SP.COMBINED.TOTL\_DS2\_en\_csv\_v2.csv

This dataset included data on:

- Country-level GDP (in USD)
- The share of different energy types (e.g., nuclear, hydroelectric) in total electricity production
- Income group classifications (e.g., Low income, High income)

### **GDP vs. Hydroelectric Power (2015)**

To examine the relationship between national wealth and energy infrastructure, the year **2015** was selected as a fixed point of analysis. The dataset was filtered to keep only the necessary columns: Country Name, GDP, and Hydroelectric (% of total). Any rows with missing values were removed.

A scatter plot was created to visualize the relationship between a country's GDP and the proportion of electricity derived from hydroelectric sources. This allowed me to investigate whether wealthier countries invest more in hydroelectric power.

### **Nuclear Power Usage by Income Group**

To explore long-term trends in nuclear energy use, the dataset was filtered to include only aggregate data for four World Bank income groups:

- Low income
- Lower middle income

- Upper middle income
- High income

The nuclear energy share (Nuclear (% of total)) was averaged by income group and year

This resulted in a time series plot showing how nuclear power usage has changed over time across different income categories. It helped to identify patterns and disparities in energy infrastructure based on economic development.

## 4. Results

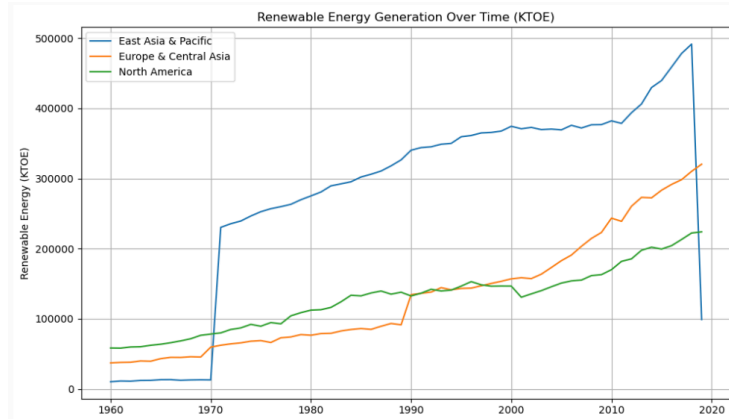
### 1. Renewable Energy Production by Region

In the first part of this analysis I looked at the amount of renewable energy (measured in KTOE) in three major regions: East Asia and Pacific, Europe and Central Asia, and North America

By grouping the data by region and year and plotting this against the amount of renewable energy produced over time. By doing this I found that all three regions had shown an increase of renewable energy production over time but with some differences in the rate of increase such as:

- **Europe & Central Asia** displayed the most rapid growth in renewable energy generation, particularly in the last decade. This suggests strong regional policies and investments supporting clean energy transitions
- **East Asia & Pacific** showed consistent growth, largely driven by industrial expansion and growing demand for energy. Countries like China have made large-scale investments in renewables in recent years
- **North America** also demonstrated a clear upward trend, though growth has been more gradual compared to the other regions. Factors such as policy changes and fossil fuel reliance may explain the more modest rise.

These trends can be observed in the screenshot below:



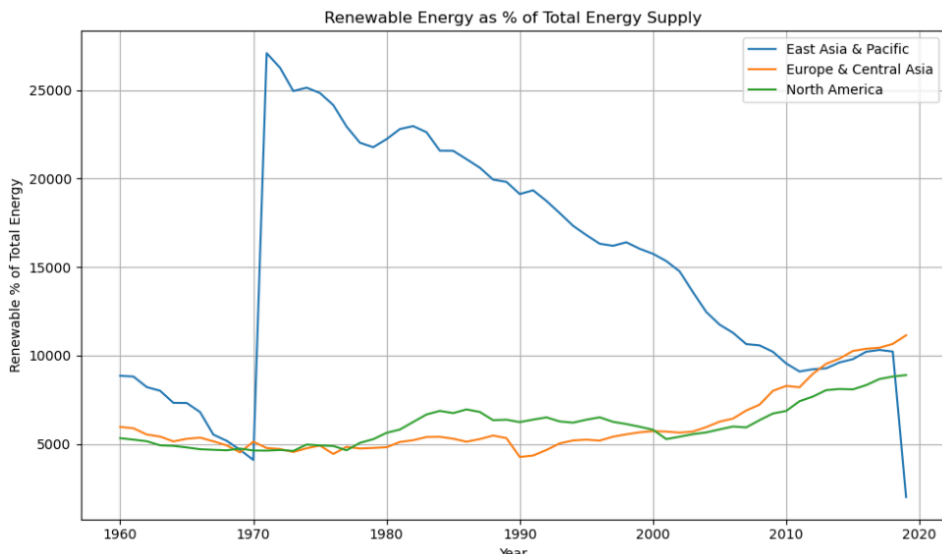
## 2. Renewable Energy as a Share of Total Energy Supply

To gain a clearer picture of how reliant each region is on renewables, I calculated the percentage of total energy supply that comes from renewable sources. This was done by dividing renewable energy production by total energy supply and multiplying by 100.

The percentage share was then plotted over time for each region. The results mirrored the absolute production trends, but with some important differences:

- **Europe & Central Asia** not only increased renewable production but also significantly increased its renewable share, indicating a strong shift away from fossil fuels.
- **East Asia & Pacific** showed steady growth in percentage share, although it started from a lower base.
- **North America** increased its renewable share too, but at a slower rate than the other regions.

This suggests that while all regions are producing more renewables, Europe is doing so more efficiently in terms of its overall energy mix.

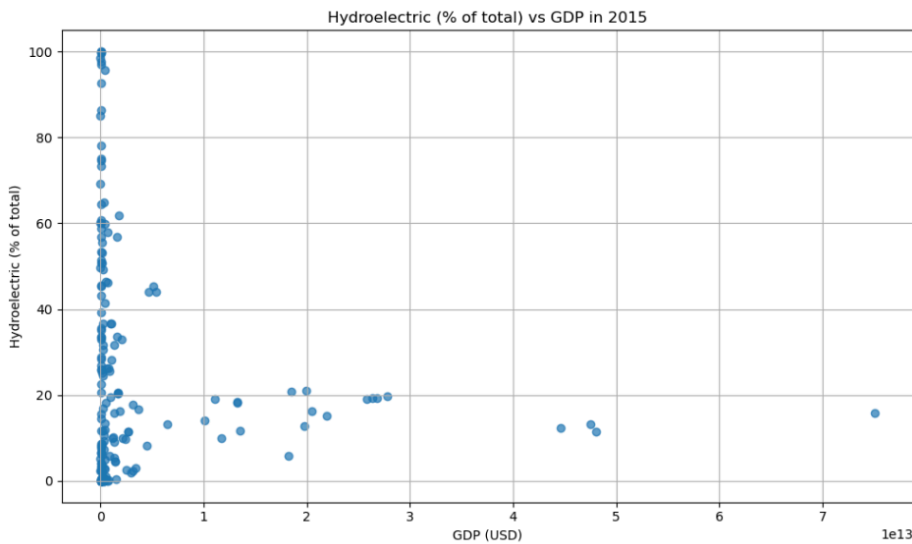


This screenshot of the plot from my code shows the above hold true.

### 3. Relationship

#### Between GDP and Hydroelectric Power (2015)

To explore the connection between economic development and energy sources, we looked at data from 2015 and created a scatter plot comparing GDP (in USD) with Hydroelectric energy as a percentage of total electricity generation.



The resulting plot suggested a loose positive relationship — countries with higher GDP tended to have a greater share of hydroelectric power in their energy mix. However, the correlation wasn't perfectly strong. Some high-GDP countries had relatively low hydroelectric use, likely due to geographic limitations or reliance on other energy sources like nuclear or fossil fuels.

Overall, the pattern supports the idea that wealthier

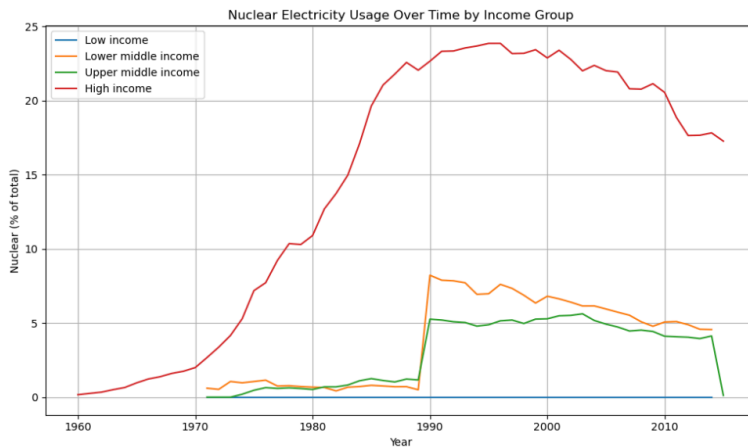
nations are more capable of investing in large-scale renewable infrastructure such as dams, but this also depends on regional geography and policy priorities.

#### 4. Nuclear Energy Usage by Income Group

The final part of the analysis examined how the use of nuclear energy (as a percentage of total electricity) varies across income levels over time. We averaged nuclear energy usage for each income group and plotted it across multiple years.

Key observations:

- **High-income countries** consistently had the highest levels of nuclear energy usage. This aligns with the expectation that nuclear infrastructure requires significant financial and technological resources.
- **Upper middle-income countries** showed a modest increase over time, suggesting growing investment in nuclear technology.
- **Lower middle-income** and **low-income** countries had very limited or no nuclear energy usage, likely due to cost barriers, safety concerns, and lack of infrastructure.



These trends highlight the economic divide in access to advanced energy technologies. While nuclear power can be an important low-emission source of electricity, its development remains concentrated in the wealthiest nations.

## 5. Discussion

### 1. Renewable Energy Growth Across

#### Regions

One of the clearest trends in the data is the steady increase in renewable energy production across all three regions analysed. This aligns with global efforts to transition away from fossil fuels due to climate concerns and international agreements such as the **Kyoto Protocol (1997)** and the **Paris Agreement (2015)**.

- **Europe & Central Asia's Leadership in Renewables:**  
The steep increase in renewable energy production in this region suggests strong policy measures, technological advancements, and investment. The European Union has implemented strict renewable energy targets and subsidies for clean energy projects, which may explain the rapid increase in the share of renewables.
- **East Asia & Pacific's Gradual but Consistent Growth:**  
While renewable energy generation in this region is increasing, the growth rate is not as steep as in Europe. This could be due to a combination of factors:
  - The continued use of coal in China and other industrial economies.
  - A high energy demand that makes full reliance on renewables difficult.
  - A gradual transition toward solar and wind energy, particularly in countries like China and Japan.
- **North America's Slower Growth:**  
The more gradual increase in North America's renewable share could be due to the

ongoing presence of fossil fuels in the U.S. energy sector, where policies on renewables have fluctuated with different administrations. However, state-level initiatives (e.g., California's push for 100% renewable energy by 2045) indicate that the region is still moving toward a cleaner energy mix, more slowly.

## **2. Renewable Energy as a Percentage of Total Energy Supply**

While renewable production has increased in absolute terms, the percentage of total energy from renewables has grown at different rates across the regions. This is a critical distinction as an increase in renewable energy does not necessarily mean a decrease in fossil fuel dependency if total energy consumption is also rising.

- **Europe & Central Asia Shows the Fastest Growth in Renewable Share:**  
The fact that Europe's percentage of renewable energy has increased significantly suggests that fossil fuel consumption has not grown as quickly as renewable capacity. This supports the idea that European countries are actively replacing traditional energy sources with renewables.
- **East Asia & Pacific Shows a Moderate Increase:**  
While the total production of renewable energy has risen in this region, the percentage share of renewables has not increased as dramatically. This suggests that overall energy demand is still rising, leading to continued reliance on fossil fuels.
- **North America Lags in Renewable Percentage Growth:**  
Despite an increase in total renewable energy, the percentage share of renewables remains relatively low. This indicates that fossil fuels still play a dominant role in the North American energy mix, possibly due to the region's large oil and gas industry and slower political commitment to reducing fossil fuel dependence.

## **3. Economic Factors in Energy Production: The Role of GDP and Income Levels**

The second part of the analysis focused on how economic factors influence energy sector contributions.

### **3.1 Relationship Between GDP and Hydroelectric Power**

The scatter plot comparing GDP and hydroelectric power usage (2015) revealed that higher-GDP countries tend to have a greater share of hydroelectric energy. However, this relationship is not perfectly strong, which suggests other influencing factors:

- **Geography Matters:** Hydroelectric power depends on the availability of large water bodies and suitable terrain. Countries with mountainous regions and large rivers are more likely to use hydroelectric energy, regardless of GDP.
- **Investment in Infrastructure:** Higher-GDP countries may have better resources for developing large-scale hydroelectric projects, but some nations choose to focus on nuclear or other renewable sources instead
- **Policy and Energy Strategy Differences:** Some high-GDP nations prefer nuclear, wind, or solar energy over hydroelectric due to environmental concerns (e.g., habitat destruction from dam construction).

### 3.2 Nuclear Energy Usage by Income Group

The trend analysis of nuclear energy usage over time across different income groups highlighted significant disparities:

- **High-Income Countries Dominate Nuclear Energy Production:** The strong presence of nuclear power in wealthier nations suggests that nuclear energy is capital-intensive and requires long-term financial stability. Countries such as France, the U.S., and the UK have well-established nuclear programs supported by government funding.
- **Upper-Middle-Income Countries Show Gradual Adoption:** Some middle-income countries (e.g., China, Russia, and India) have started investing in nuclear power, though at a slower pace due to high initial costs and regulatory challenges.
- **Lower-Middle and Low-Income Countries Have Minimal Nuclear Energy Use:** The data shows little to no nuclear energy usage in lower-income groups. The reasons for this include:
  - High costs and technical expertise required.
  - Political and environmental concerns about nuclear waste.
  - Greater focus on cheaper and more accessible energy sources like coal and hydropower.

These findings highlight the economic divide in energy infrastructure development while high-income nations have the financial and technological capacity to pursue nuclear energy, lower-income countries remain reliant on cheaper, more traditional energy sources.



## 6. Conclusion

### Limitations and Areas for Further Research

While the results offer valuable insights, there are some limitations to consider:

- **Data Gaps and Missing Values:** Some countries may have incomplete or missing data for specific years, which could affect the accuracy of trends. Future studies could use data interpolation techniques to improve coverage.
- **Policy and Regulatory Influence:** The analysis does not account for country-specific energy policies, which can heavily influence renewable and nuclear energy growth. Incorporating qualitative policy analysis could provide deeper insights.
- **Energy Storage and Grid Limitations:** The study focuses on energy *production*, but energy storage and distribution infrastructure also play a critical role in how effectively renewable energy is used. Further research could explore how storage capacity and grid modernization impact energy transitions.
- **Broader Regional Comparisons:** While this study analysed three major world regions, expanding the research to include Sub saharan Africa, South Asia, and Latin America/Caribbean could offer a more comprehensive global perspective.

### Implications and Future Outlook

The findings of this study reinforce the idea that economic and policy factors play a crucial role in shaping energy transitions.

- **Europe is leading the global shift to renewables**, while other regions are still in varying stages of transition.
- **Higher-income nations continue to dominate nuclear energy use**, while lower-income nations face barriers to entry.
- **The future of renewable energy depends not just on production but also on grid modernization, storage solutions, and political will.**

Looking ahead, further advancements in **battery storage, international cooperation, and technological innovations** will likely play a crucial role in accelerating the transition to cleaner energy sources worldwide.