



Data Visualization Pitch  
Student Individual Assignment

# Electricity around the world

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Image: Marghera Thermolectric central

## Research questions

This research aims to explore and compare the various energy sources around the world, comparing different areas, fuels and emissions. We will try to answer the following questions regarding the production of electric energy.

- How does the electricity production mix has evolved around the world in the last 25 years?
- What is the impact on emissions of different fuels?
- Which countries are guiding the transition to a cleaner energy mix?
- Which countries are the most impactful on emissions?
- When it comes to renewables, is there a discrepancy between capacity increase and actual production?

This presentation ultimately provides a data-driven perspective on political debates related to environmental and economic issues, highlighting the quantitative scale behind them.

## About Data

Dataset: Ember "**Yearly electricity data**" (<https://ember-energy.org/data/yearly-electricity-data/>)

The Dataset, curated by Ember, contains yearly electricity generation, capacity, emissions, import and demand data for over 200 geographies. The dataset covers a span of 25 years, starting from 2000 up to 2024. It is based on official reports from each area it covers.

Ember's website doesn't include any specific licensing rule as the goal of the organization is to provide fully open data with the goal of accelerating electricity transition.

The Data is clean and well structured, and Ember provides a detailed guide for understanding each parameter. This guide also contains the sources of the data.

Guidelines: [https://files.ember-energy.org/public-downloads/ember\\_electricity\\_data\\_methodology.pdf](https://files.ember-energy.org/public-downloads/ember_electricity_data_methodology.pdf)

## Methodology

- **Data Collection:** Many energy related datasets were explored before picking this specific one, which provided clean, well organized and comprehensible data.
- **Data Processing & Cleaning:** Data was analyzed in a jupyter Notebook with the following Python libraries: Pandas, numpy, Matplotlib, Plotly.
- **Data Transformation:** The analysis required to create subsets of different geographical areas. More specific dataframes were later handpicked, ordered and normalized to further investigate phenomena.
- **Use of AI Tools:** AI was used to quickly generate large and modular code blocks, in order to organize and color-code visualizations.
- **Analytical Techniques:** I adopted a top-down approach, starting from more general and explorative visualization and then switching to more specific questions. My main focus was spotting trends and outliers.
- **Reproducibility:** The Data is open and available, many more questions can be explored through it.

## Insights from the Data

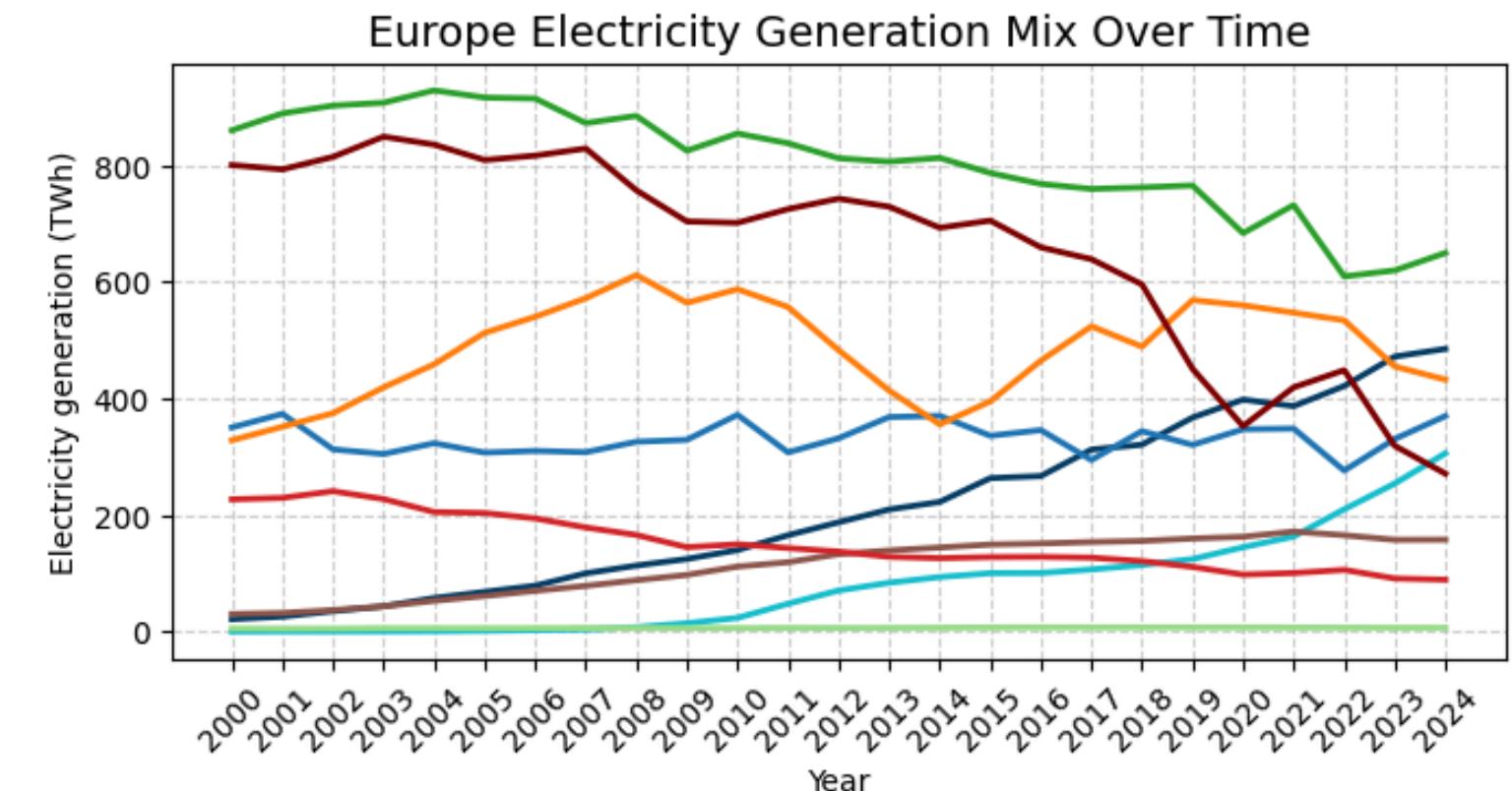
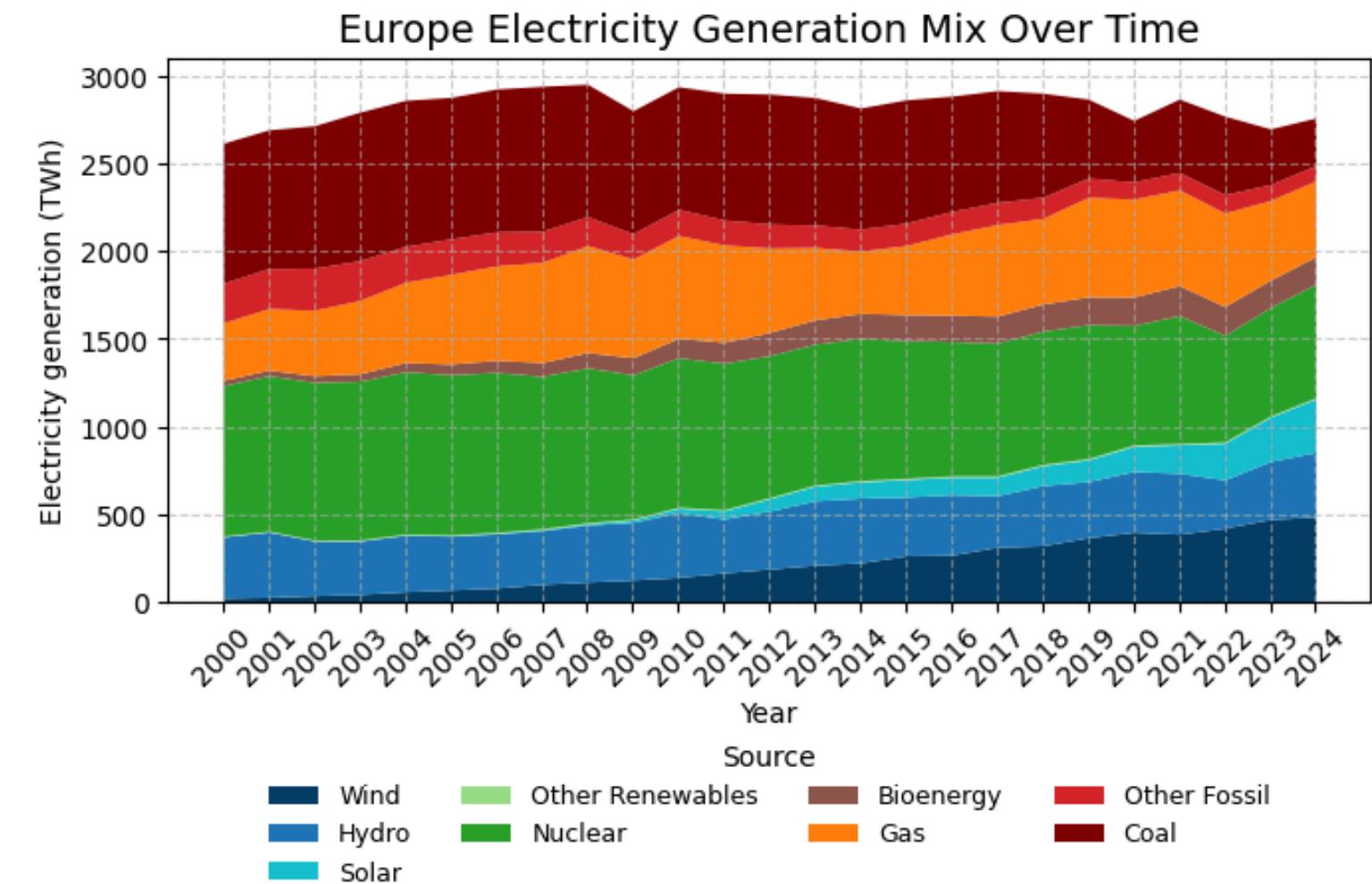
- Data structure. The dataset is organized by country and consists of a time series covering the period from 2000 to 2025. For each country and year, it reports multiple electricity-related indicators.
- The analysis focuses on three key variables: capacity (GW), generation (TWh), and emissions (mtCO<sub>2</sub>).
- After 2022, data for most African countries are missing, which may introduce inaccuracies in slide 13.
- Throughout the analysis, values reported under the "Fuel" category were used, then aggregated and normalized to ensure consistency across countries and time.
- The fuel categories are: Wind, Hydro, Solar, Nuclear, Bioenergy, Gas, Other fossils, Coal.



### Trends in electricity generation in Europe. (continent)

The graph represents how each fuel has contributed to the total production of electricity in the European area (36 countries, Russia included). The data is both represented in areas and lines, to describe how the total production has evolved (areas) and better visualize the trend for each fuel (lines).

- **Coal and Other fossil:** Starting from 2007, a clear downward trend in coal and other fossil-based electricity generation emerges across Europe. This evolution aligns with the gradual strengthening of EU climate policies, notably the early phases of the EU Emissions Trading System and the policy framework leading to the 2008-2009 Climate and Energy Package.
- **Gas:** Until 2008, gas exhibits a steady expansion within the energy mix; however, when considering the full time horizon, its overall net variation remains limited, reflecting a transitional rather than structural role.
- **Nuclear:** Nuclear energy represents a substantial share of electricity generation in the European area. The persistent decline observed after 2004 has significantly constrained growth in total electricity output across the region.
- **Hydro, Solar, Wind:** They all fall into the renewable category, and have shown a constant growth in the mix over the last few years. In particular, **Wind**, is shaping up to be a major player in electricity production in the European area. **Hydropower** stands out as the most stable energy source, as its production is tightly linked to existing infrastructure. Given a fixed number of dams and plants, electricity generation remains largely constant over time, except in periods of severe drought.



## The Big Players in nuclear - Europe

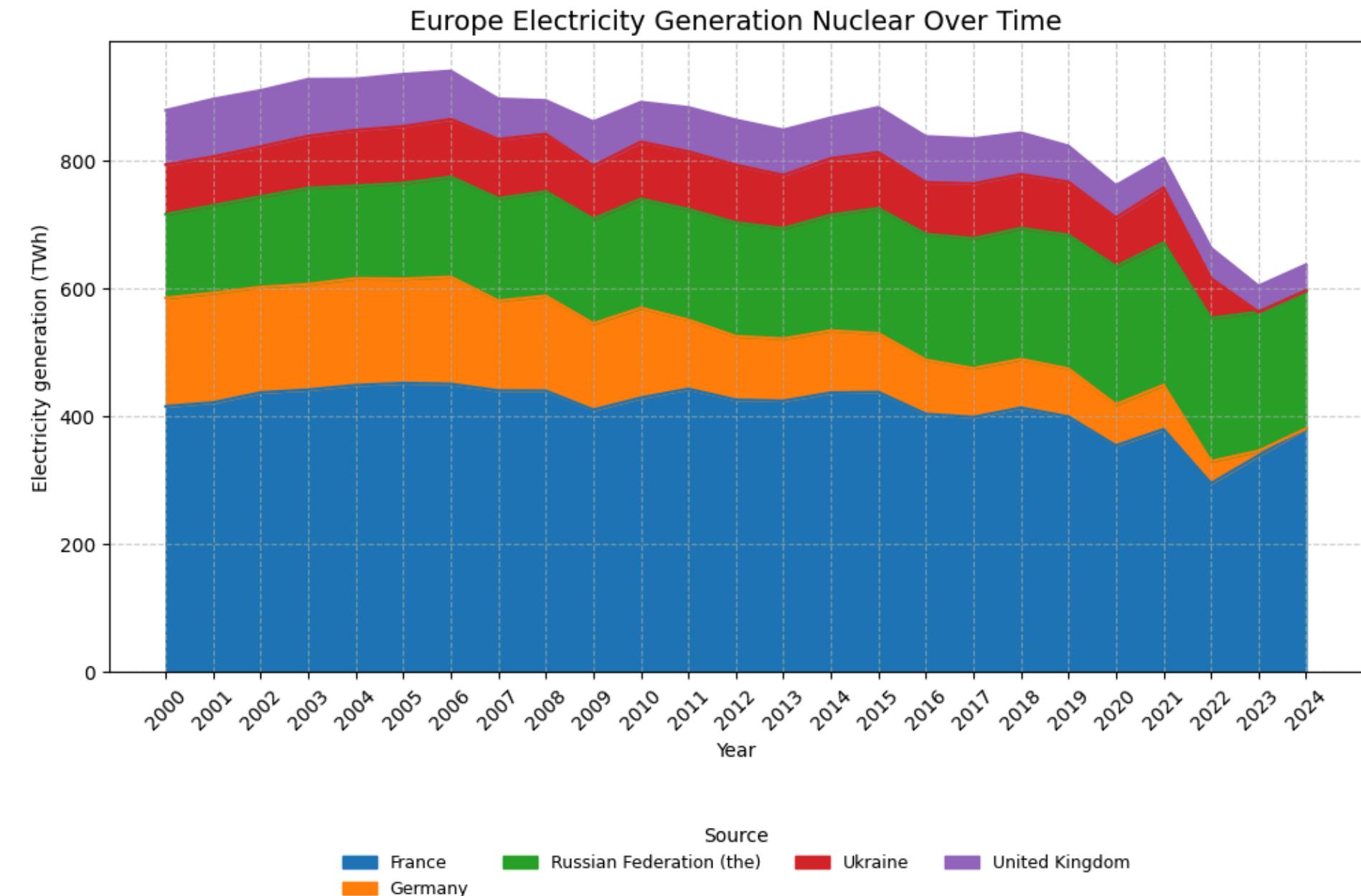
As previously noted, nuclear power has experienced a net decline over the past two decades. The graph illustrates how nuclear electricity production has evolved among the five largest producers in the region.

Germany shows a pronounced and sustained reduction over time, reflecting a strategic shift toward a more renewables-oriented energy mix, as will be discussed in the next slide. In 2022, the Ukrainian region of Zaporizhzhia was annexed by Russia, completely shutting down nuclear fueling in the area.

France remains by far the dominant nuclear producer in the region, with 57 operable reactors. Between late 2021 and 2022, extensive maintenance inspections revealed critical faults across several reactors. These findings prompted the issuance of a €1 billion loan aimed at improving plant safety and operational reliability.

(<https://world-nuclear.org/information-library/country-profiles/countries-a-f/france>)

This particular occurrence is clearly displayed in the graph, with a dip in production between 2021 and 2022.



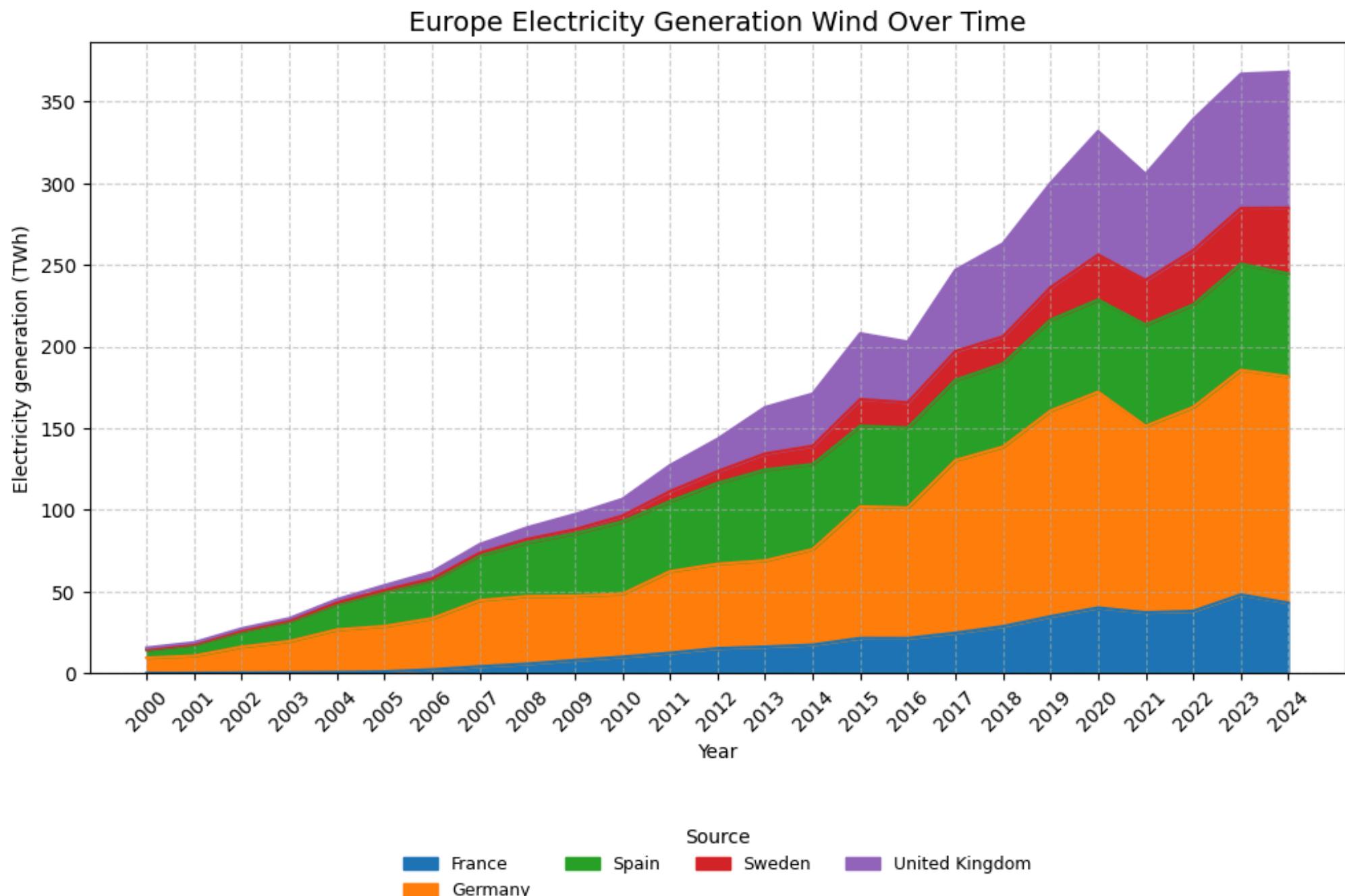
## The Big Players in wind - Europe

Who are the real MVPs when it comes to renewables?

The graph illustrates the evolution of wind-based electricity production among the five largest producers in the region.

Germany clearly stands out as the leading country in wind-generated electricity. Building on this strong performance, Germany is planning a further expansion of capacity through the deployment of new onshore wind facilities, as reported by [Clean Energy Wire](#).

Consistent with the overall generation mix, wind power exhibits the largest relative increase over the past 25 years in Europe. This structural shift is particularly evident in countries that pioneered early and large-scale investments in wind energy.

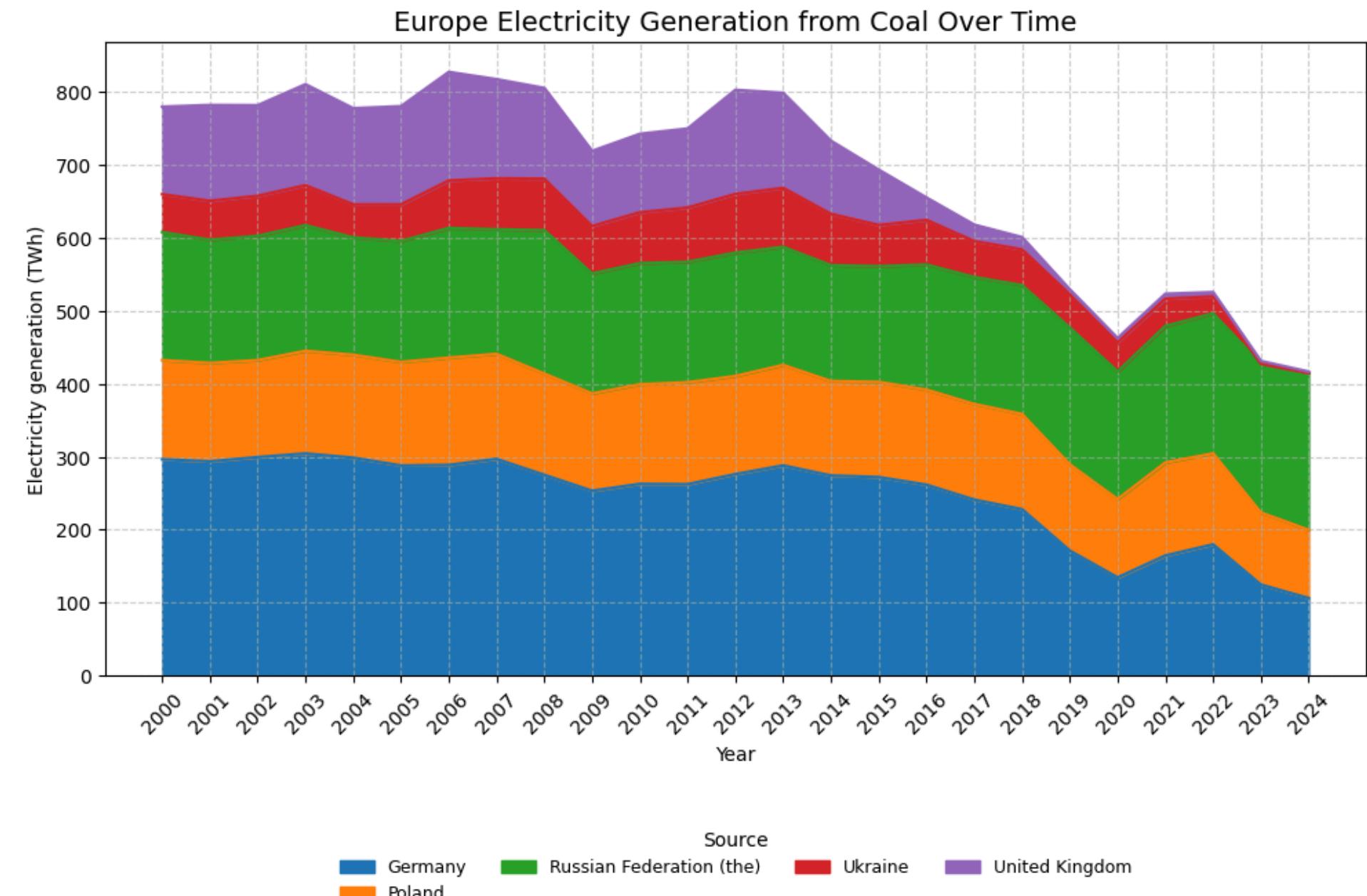


## Reducing Fossil in the energy mix

Which countries have most effectively implemented emission reduction strategies?

The graph illustrates the evolution of coal-based electricity production among the five largest coal users in the region.

The United Kingdom and Germany stand out for the sharp reduction in coal generation, largely driven by the successful deployment of wind energy, which has significantly reduced their reliance on coal-fired power. By contrast, the graph highlights that Poland and Russia remain strongly dependent on coal, with electricity production still heavily fuelled by this source, indicating a slower transition away from fossil-based generation.



## Comparing capacity and generation.

The charts compare percentage changes in installed capacity and electricity generation across renewables, nuclear, and fossil fuels. Capacity is used as a proxy for infrastructure investment.

Fuels and their capacity have been grouped in:

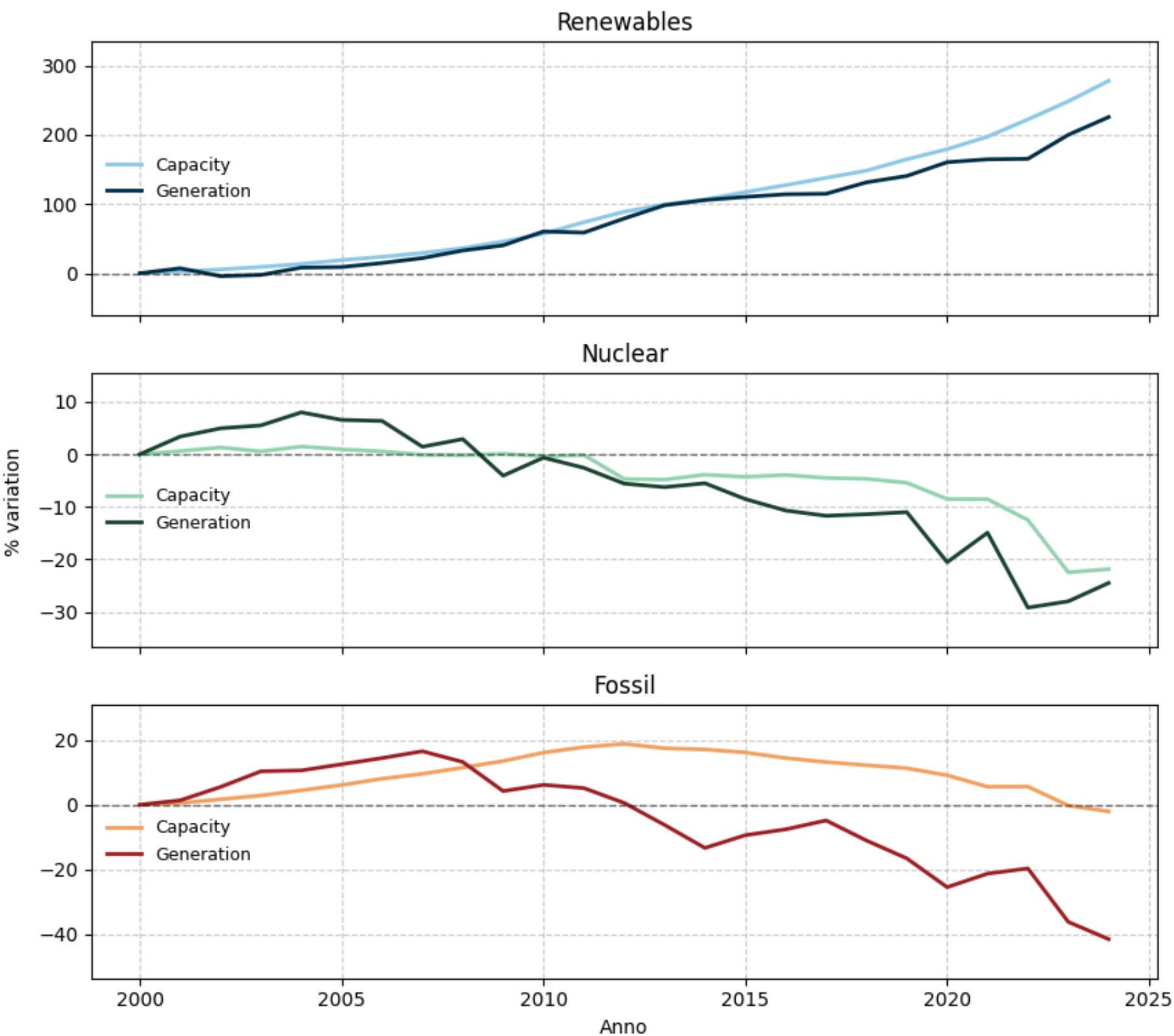
- 1 - **Renewables**: Wind, Hydro, Solar, Bioenergy
- 2 - **Nuclear**.
- 3 - **Fossil**: Coal, Gas, Other Fossils.

**Renewables** show a strong and nearly proportional increase in capacity and generation (~250% vs ~230%), indicating that investments have largely translated into higher output despite weather dependency.

Both **nuclear** and **fossil** fuels have experienced a reduction in electricity generation. However, capacity trends diverge significantly between the two. Nuclear energy, being the subject of intense political and regulatory debate, has seen a substantial contraction in capacity across the region. Fossil-based infrastructure, by contrast, has undergone only a marginal net reduction, despite producing less electricity overall and accounting for higher emissions.

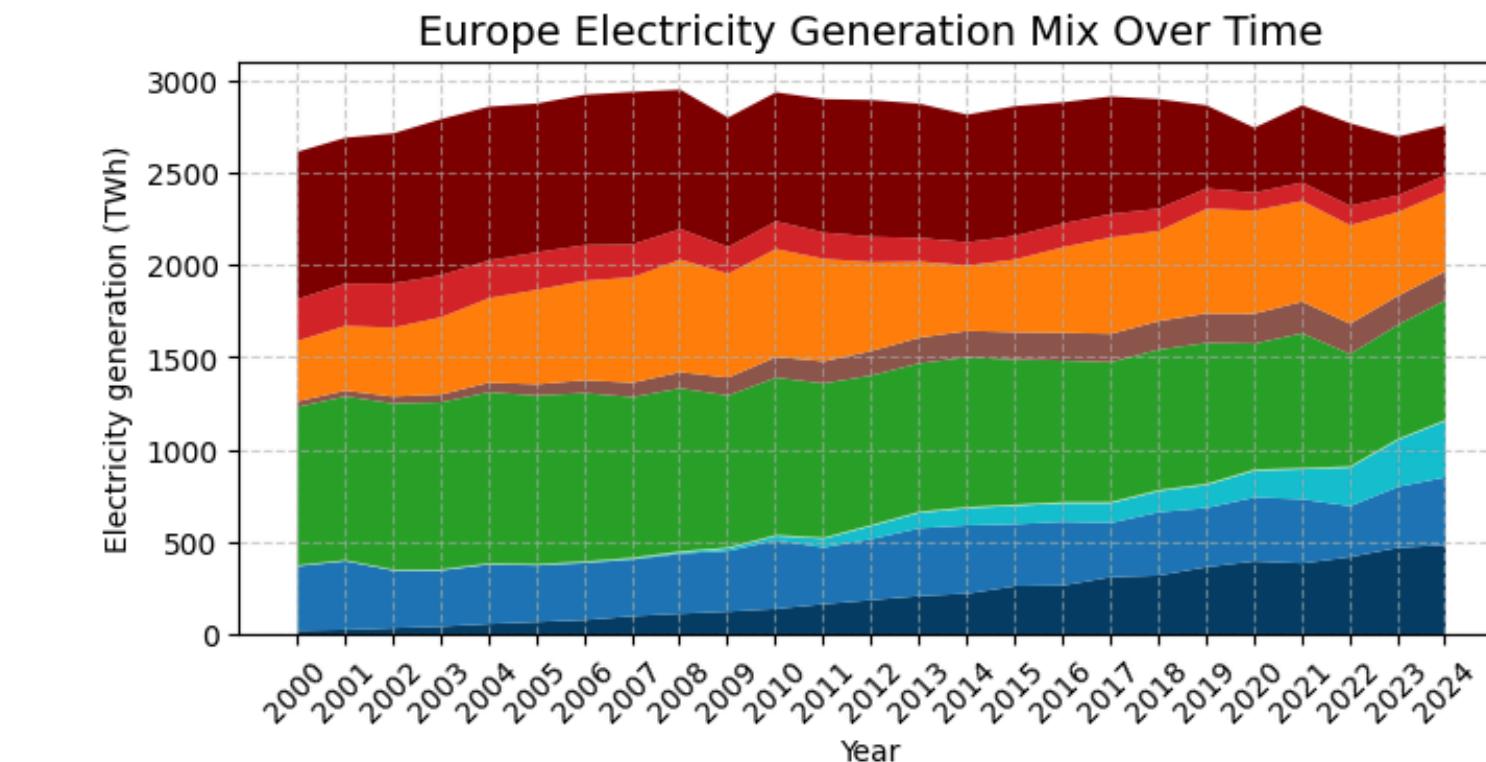
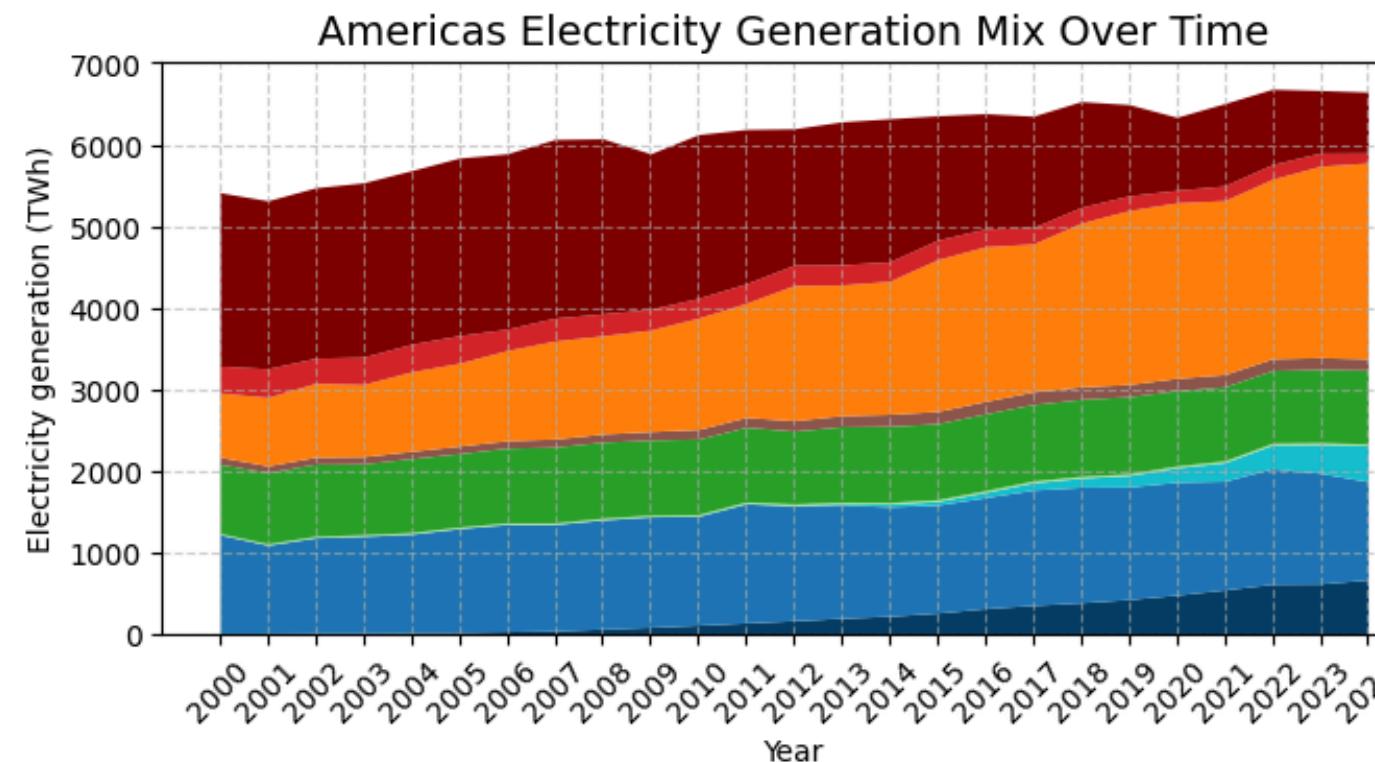
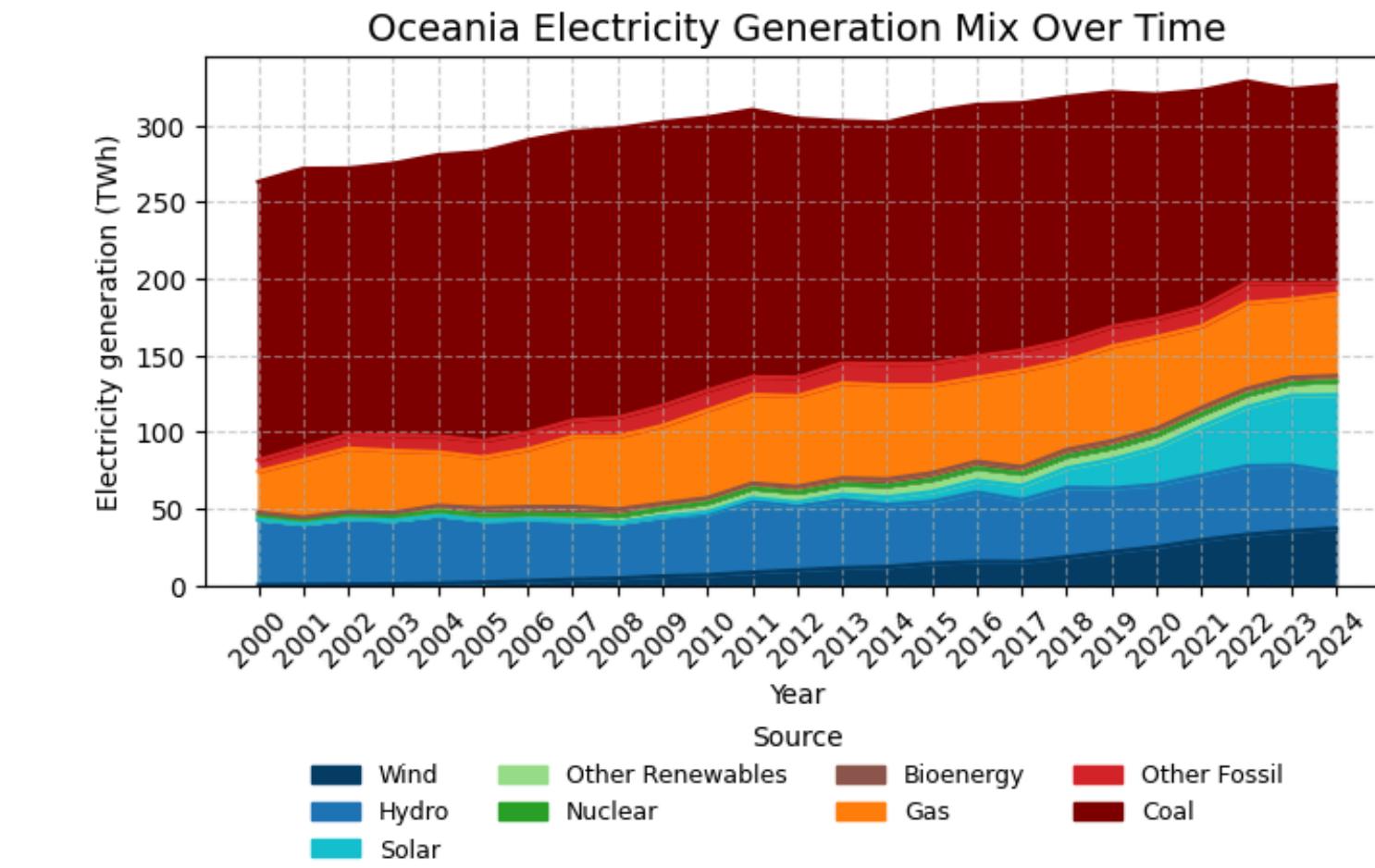
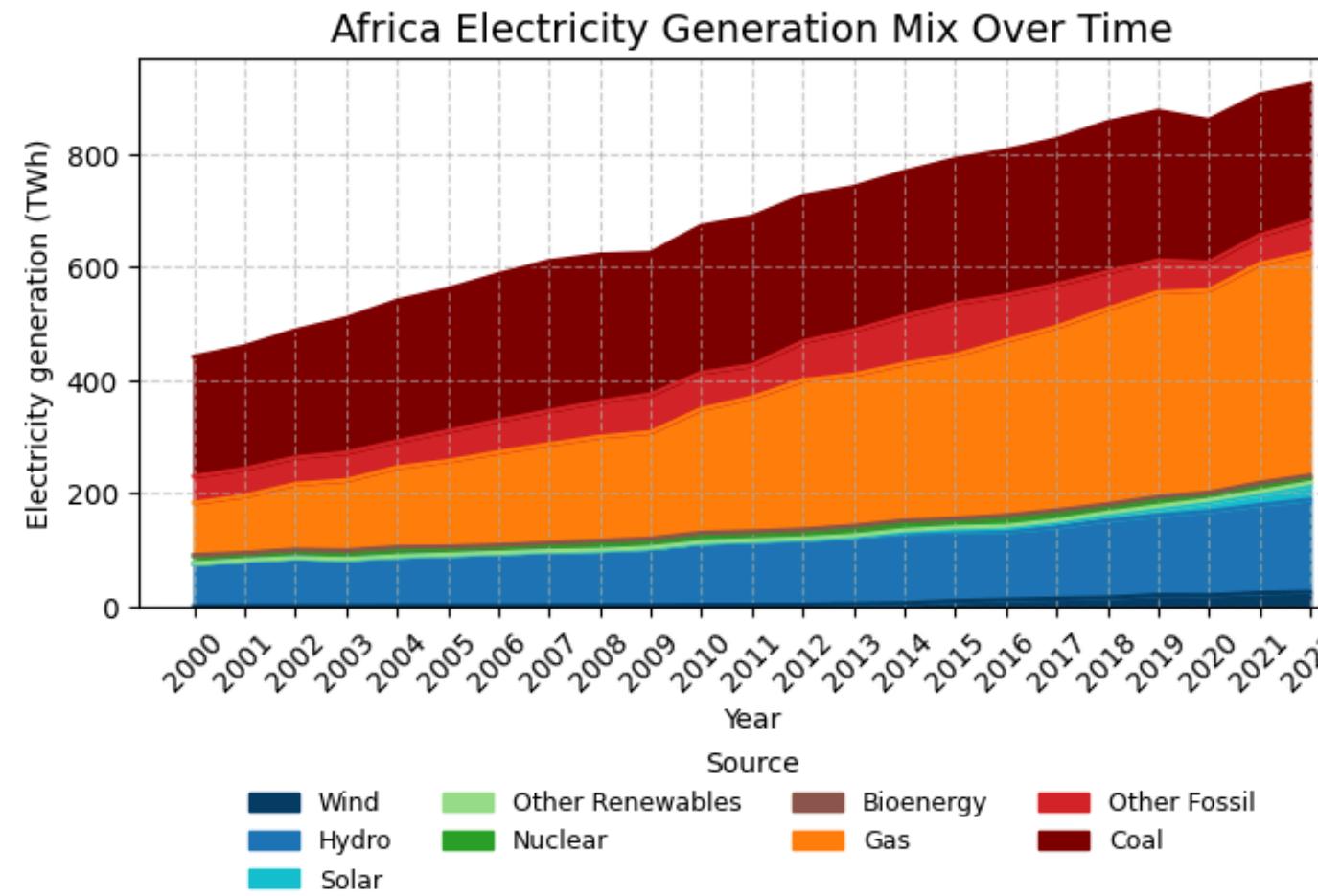
In the last 15 years, the area is slowly starting to dismiss its fossil based implants, However, the overall strategy remains conservative, as fossil-based plants are still required to retain sufficient capacity to cover demand in the event of energy supply shocks or periods of system stress.

Europe (continent) - Capacity vs Generation: % change from 2000 by fuel category



# A worldwide perspective

Each graphs represents a different continent's energy mix. The total output stands at different levels , with Europe and America's being the biggest producers. Africa has been limited to 2022 due to several missing values.

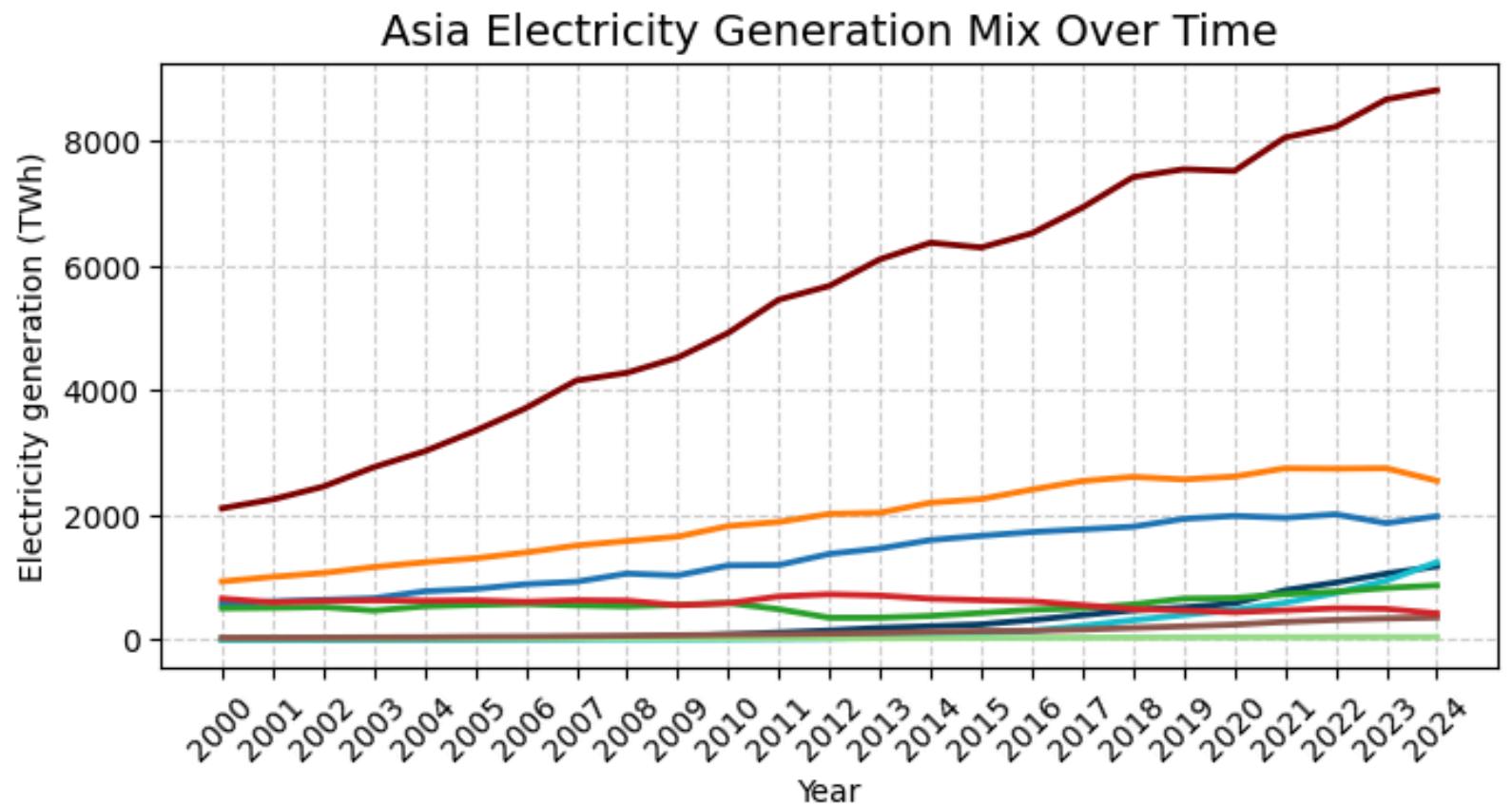
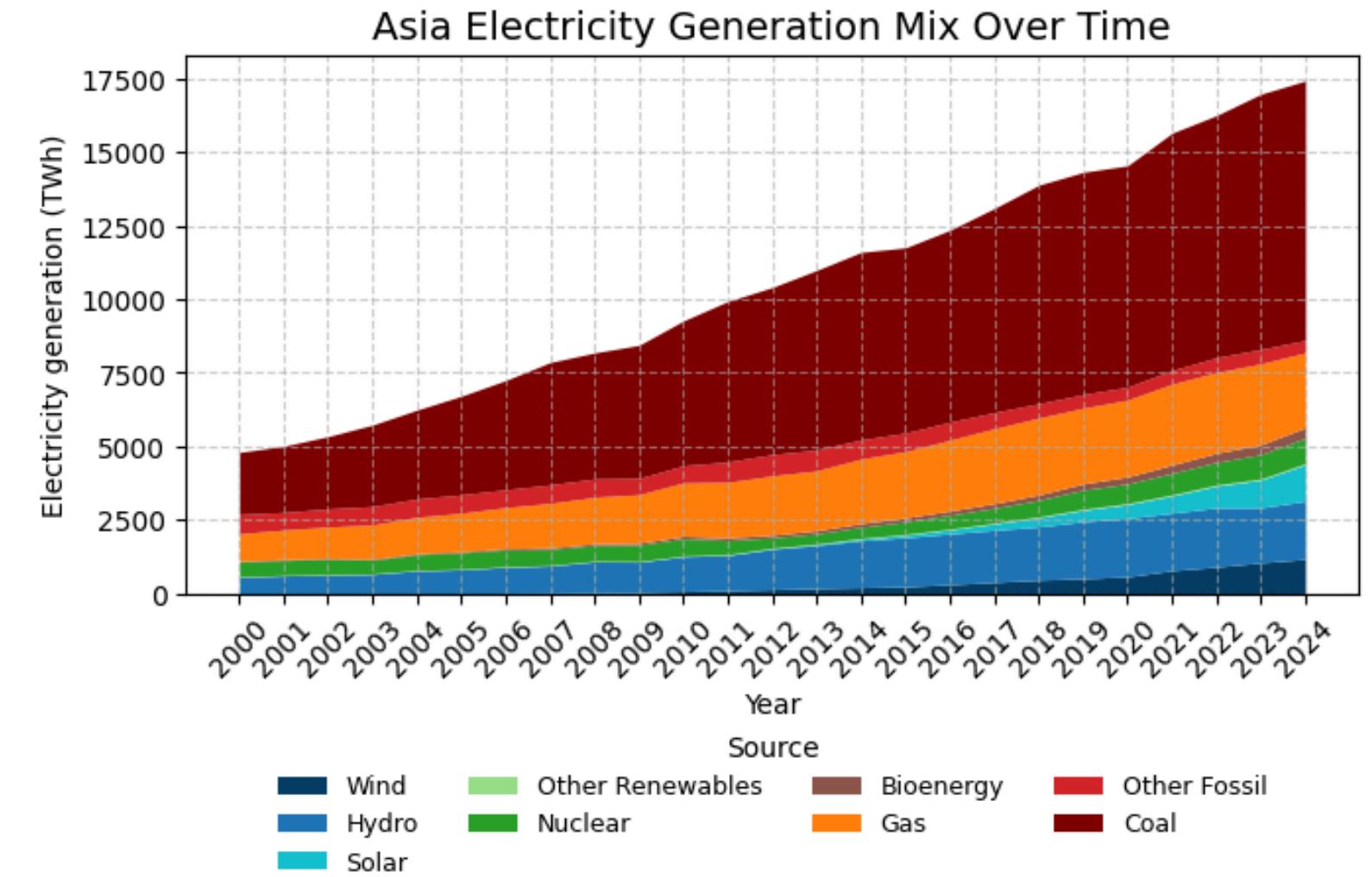


## Asia and the fossil giant of China

As in the previous slide, most continents show a gradual shift away from coal alongside growing investments in renewables. Asia, however, represents a clear exception, with a sustained and steep increase in coal-based electricity generation.

The graph represents how each fuel has contributed to the total production of electricity in Asia. Data is both represented in areas and lines, to describe how the total production has evolved (areas) and better visualize the trend for each fuel (lines).

- **Coal:** Electricity generation from coal has increased by over 400%, remaining the dominant driver of total output growth.
- **Nuclear:** Compared to Europe, nuclear plays a relatively minor role in Asia's energy mix.
- **Hydro, Solar, Wind:** While still marginal in absolute terms, these sources have experienced strong growth over the last decade, signaling an emerging diversification of the energy mix.



## What's the real cost of Asia's energy mix?

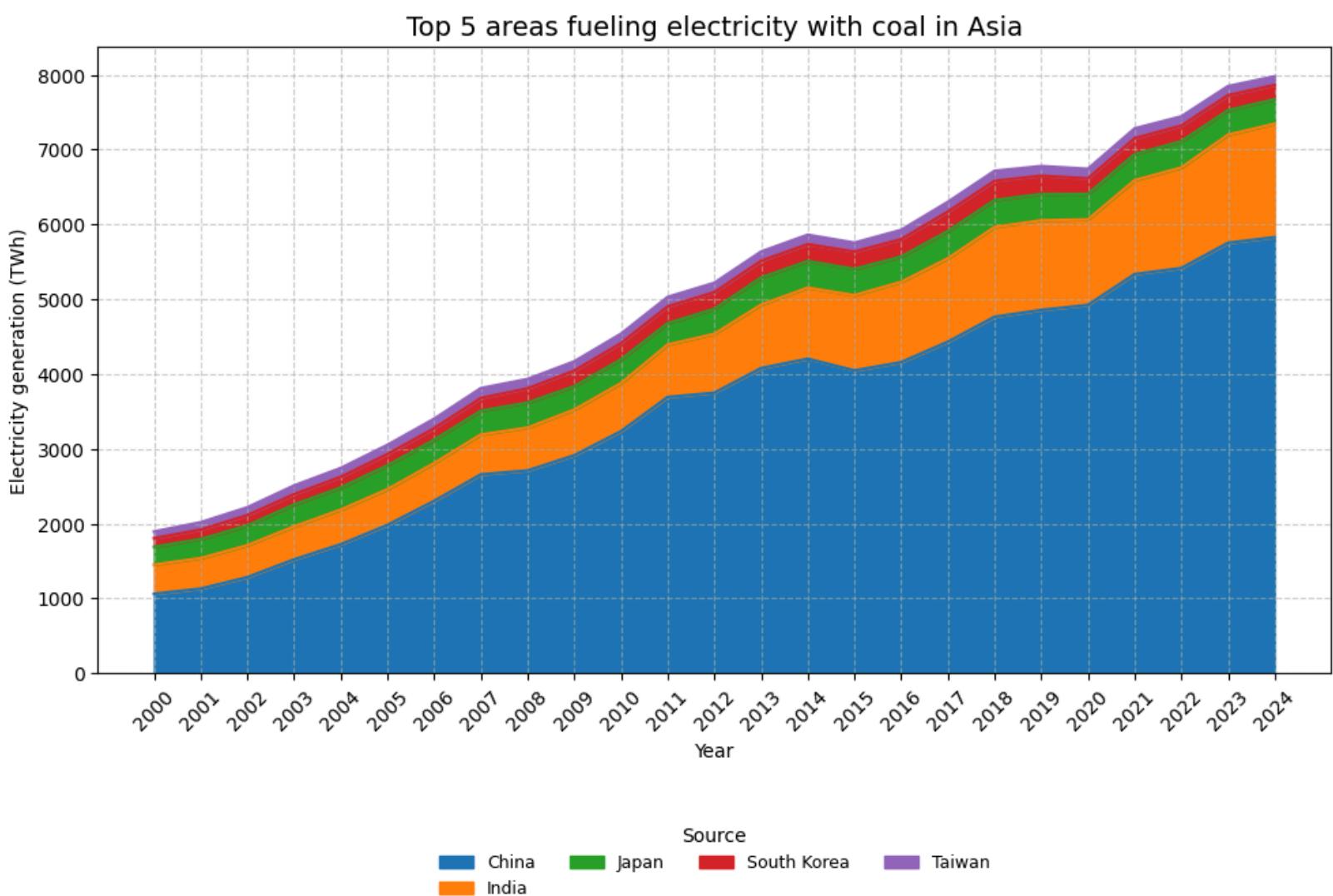
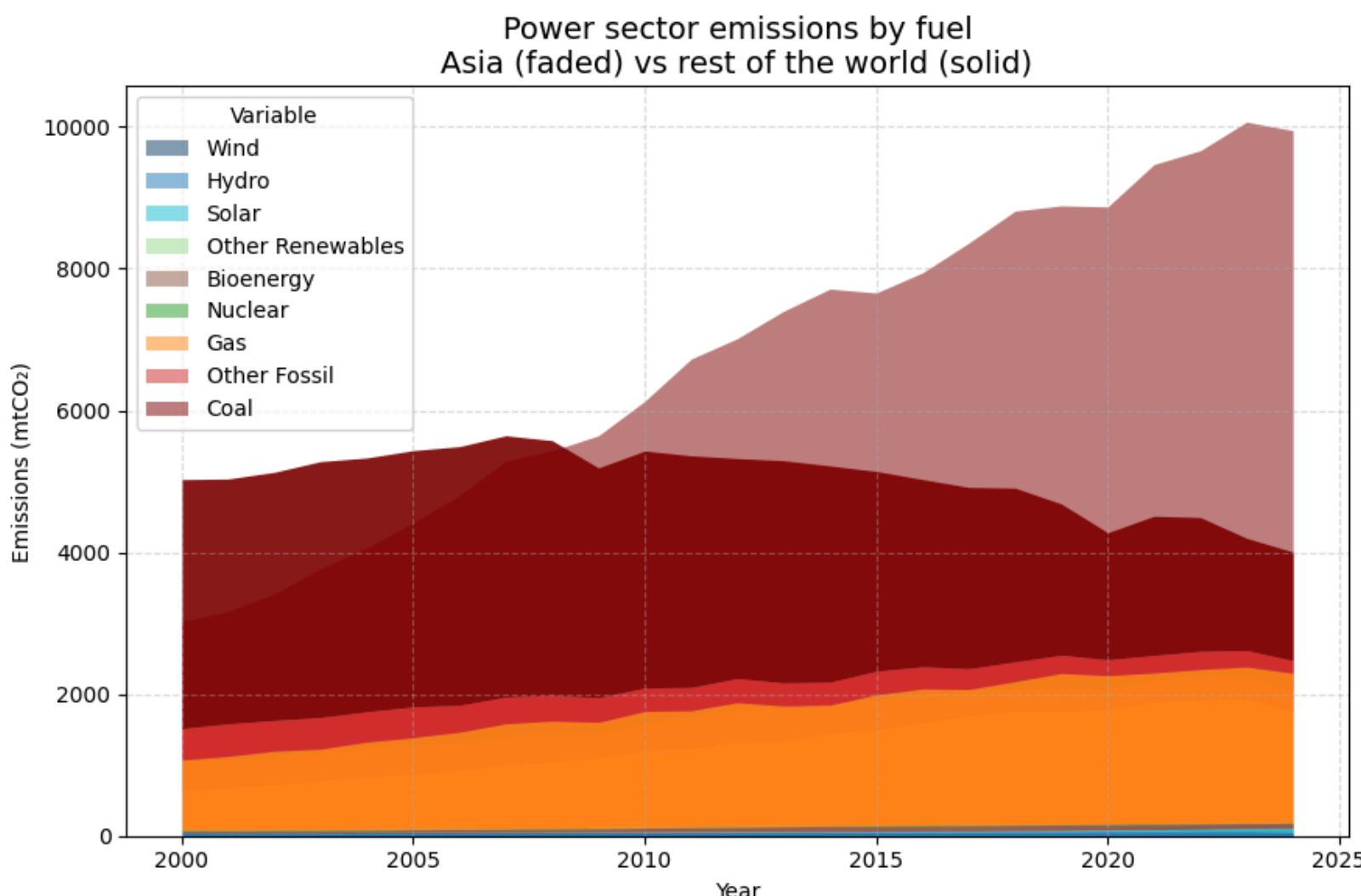
Given Asia's size and population, a direct per-area comparison of emissions would be heavily biased.

The graphs compare power-sector emissions in Asia with those of the rest of the world, highlighting that electricity generation in Asia now produces more than double the emissions of all other regions combined.

Since 2000, emissions from Asia's power sector have more than tripled, largely offsetting emission reductions achieved in Western economies.

Coal remains the dominant source of these emissions, with China accounting for the largest share of coal-fired electricity generation, as shown in the second graph.

Despite having comparable populations (~1.4 billion in 2024), [China's](#) electricity production vastly exceeds [India's](#), reflecting China's higher level of industrialization and energy intensity.



asia (continent) - Capacity vs Generation: % change from 2000 by fuel category

## How has Asia's energy capacity evolved?

The charts compare percentage changes in installed capacity and electricity generation across renewables, nuclear, and fossil fuels. Capacity is used as a proxy for infrastructure investment.

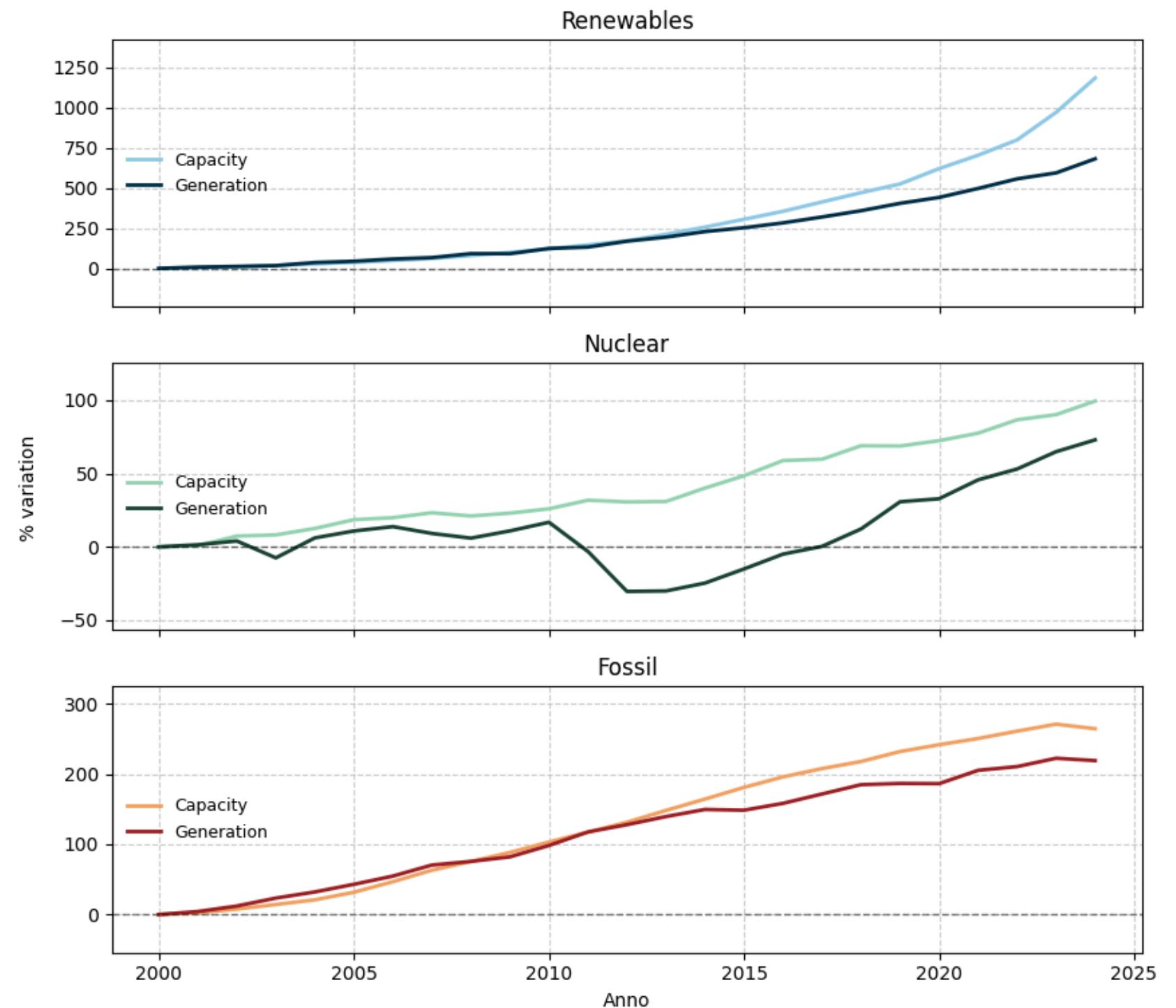
Fuels and their capacity have been grouped in:

- 1 - **Renewables**: Wind, Hydro, Solar, Bioenergy, Other
- 2 - **Nuclear**.
- 3 - **Fossil**: Coal, Gas, Other Fossils.

Despite Asia's strong reliance on fossil fuels, renewable capacity has expanded dramatically, exceeding a 1000% increase in 2024 relative to 2000.

Fossil fuels have also experienced substantial growth, with both installed capacity and electricity generation increasing by over 200%, reflecting the region's sustained demand for energy.

Nuclear capacity shows an overall increase of approximately 100%, but with a pronounced dip around 2011, which will be examined in the next slide.

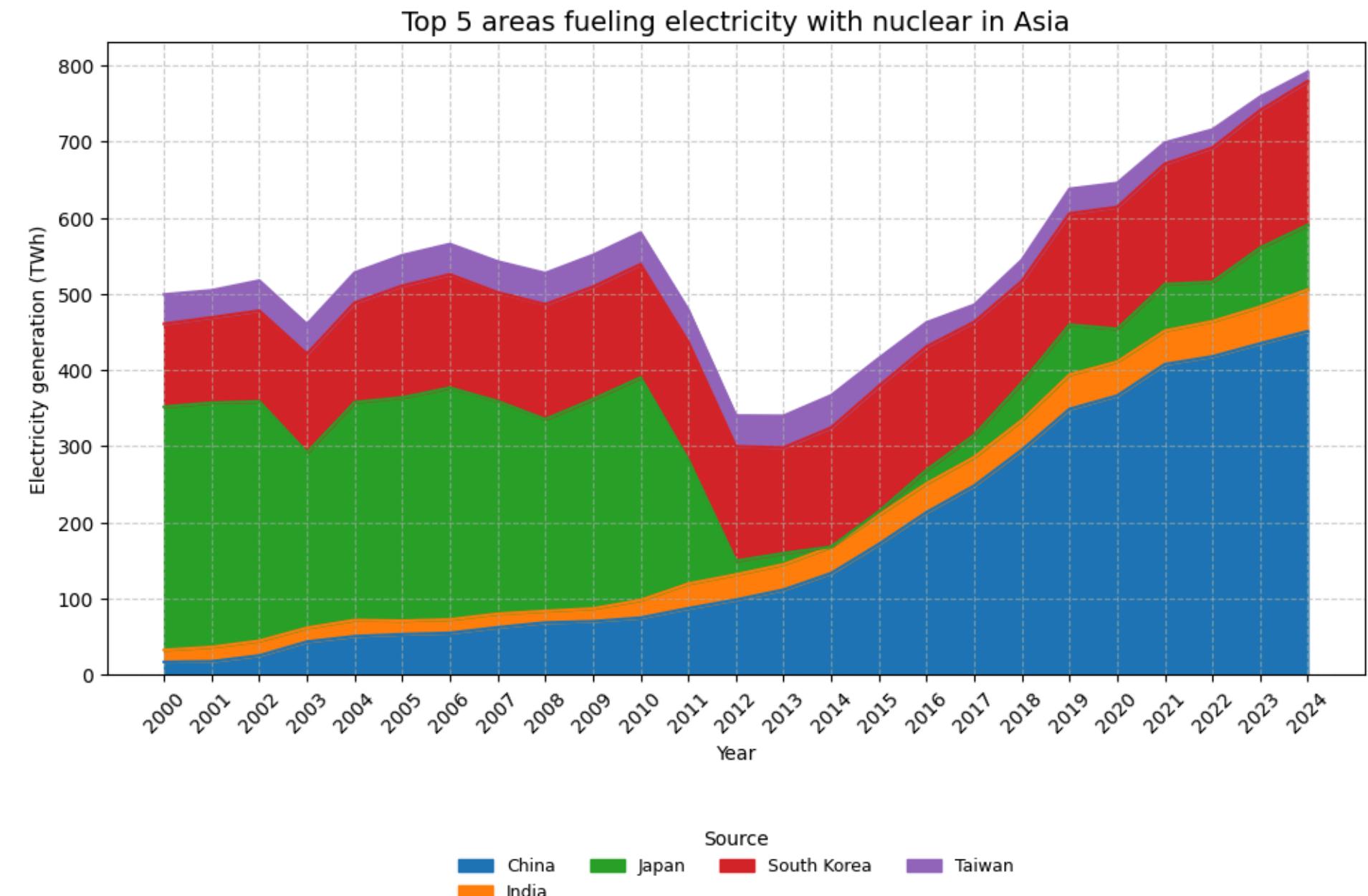


## Nuclear in Asia

The graph displays the top five countries in nuclear electricity production in Asia. Japan, which was a major producer until 2010, experienced a sharp decline in output following the Fukushima Daiichi nuclear accident in March 2011. An earthquake and tsunami caused multiple reactor meltdowns and extensive radioactive releases, forcing the evacuation of more than 150,000 people and leaving large areas uninhabitable for years.

In the aftermath, Japan halted all nuclear operations and abandoned plans to expand nuclear capacity, prompting a major realignment of national energy policy toward fossil fuels and renewables. Nuclear power, which once accounted for about one third of Japan's electricity, dropped to near zero generation in the years that followed.

The disaster also had wider political and social repercussions beyond Japan: it reshaped public attitudes toward nuclear energy in many countries and triggered policy shifts, including accelerated nuclear phase-outs in Germany and revisions of nuclear plans elsewhere.



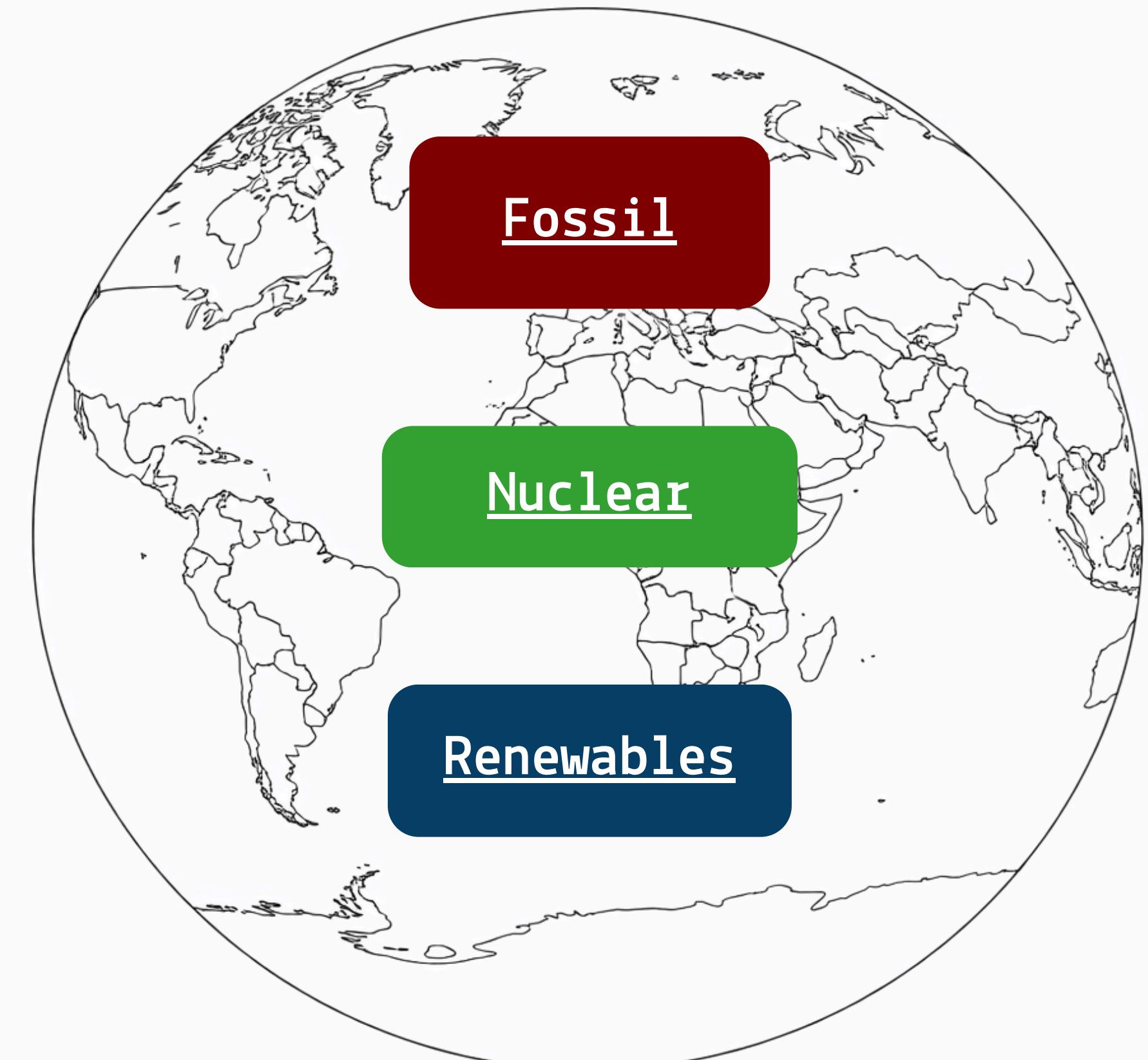
# Which energy sources do countries truly depend on? - Find out!

To move beyond absolute production volumes, this visualization adopts a relative perspective on energy dependence. The objective is to show how strongly each country relies on specific energy sources over time, rather than how much electricity it produces in total.

This approach reveals structural differences that would otherwise remain hidden: countries with very large energy systems do not necessarily appear as the most reliant on a given fuel.

For example, despite China's dominant fossil-based production in absolute terms, it does not emerge as the most fossil-dependent country, while France consistently stands out for its sustained reliance on nuclear power.

Electricity generation data were first aggregated by country, year, and energy group (Emission Free Sources, Nuclear, Fossils). For each country-year, the share of each energy group was computed as a percentage of total national electricity generation. These shares were then min-max normalized across countries for each year and energy group, resulting in a relative index scaled from 0 to 100.



## **ABOUT EMBER ENERGY:**

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**Mission:** We create targeted data and policy insights that accelerate the transition to a clean, electrified energy future.

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**Thank you!**

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