Environmental and Energy Trends in the EU: CO_2 emissions, Renewable Energy and Investments

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https://lookerstudio.google.com/s/p4w8uzwdh2A

Summary

1 Introduction: context, objectives and target audience

'Environmental and Energy Trends in the EU: CO_2 emissions, Renewable Energy and Investments' is a project aimed at **European Council**, the European Union organ institution that defines the general political direction and priorities of the EU (European Council). By analyzing key data from the second decade of the 21st century, the objective is to **inform** how EU policies have shaped the transition to renewables sources. Financing energy transition can make the EU a global leader in a sector where investment is beneficial.

1.1 Story Narrative

1.1.1 Environmental politics and investment opportunities in the European Union

Climate change is one of the central challenges of the new millennium, caused by an **ever-increasing demand for energy**. The European Union stands out not only globally, but also among OECD countries, for its cohesive and forward-looking **environmental policies**: these include **Sustainable Development Goals** (SDGs) 12 and 13 and the ratification by all member countries of the **Paris Agreement**, both in 2015. In the same year, the European Union launched the **Energy Union**, aiming to ensure secure, affordable, and sustainable energy by integrating energy policies and fostering cooperation among member states.

Furthermore, the European Union has set a **target**, to be achieved by **2030**, of having a **45 percent share of energy from renewable sources in gross electricity consumption** (European Parliament, 2023). This legislative environment, combined with increased environmental awareness among European citizens, has made the investment in energy transition a priority. With plans such as REPowerEU and InvestEU, that offer various incentives to companies aiming to increase renewable energy consumption, the renewables market has spurred and has become ideal for **long-term investment**.

1.1.2 Evolution of the Renewable Energy Market (2010–2020)

The project analyzes data from the European Union from **2010** to **2020**, a period of major energy changes but with a relatively **stable economic and geopolitical set-up**: this gives the reader the tools to accurately analyze the effects of new technologies as opposed to fossil-based sources. The only exception in this period is the year of the **COVID-19 pandemic**; however, in the data analyzed, this did not result in economic turmoil, keeping the overall picture stable. Due to the regulatory complexity associated with nuclear energy, this was excluded from the representation.

From 2010 to 2020, the **renewables market grew solidly**, thanks to the increasing energy efficiency and affordability of these technologies. There was a **large decrease in CO_2 emissions** (one of the main climate-altering gases) for all European countries. Progress toward **decarbonization** has also been ensured by **increased energy efficiency**, leading to a **decrease in electricity consumption**. This is the result of using renewable energies for electricity generation, as they ensure not only more efficiency, but thanks to their accessibility also greater energy availability and better grid management.

1.1.3 New Challenges and Future Perspectives

To this rather stable picture it is necessary to add a major turning point in renewable energy production and consumption, that is **Russia's invasion of Ukraine in 2021**: it pushed the EU to greater **energy independence** from Russian gas, culminated into the presentation of the REPowerEU plan in 2022. The need for a **secure energy source** gave a substantial boost to the consumption and production of renewables and accelerated the energy transition towards the 2030 targets.

In the area of energy transition and renewable energy, the EU must compete with two giants such as **China** and the **United States**. However, its cohesive, forward-looking and ambitious policies, if supported by long-term investment, present a great opportunity for the EU to consolidate its position as a leader in this market.

2 Datasets used in the project

The datasets analyzed are the following ones: 'Sustainable Energy Investment Forecast Dataset' and 'Invested in renewables – The only way forward'.

2.1 Description of the dataset 'Sustainable Energy Investment Forecast Dataset'

This dataset, which can be found at the following link https://www.kaggle.com/datasets/zelihayb/sustainable-energy-investment-forecast-dataset/data, contains key indicators for **sustainable energy** and **environmental** analysis, such as per capita CO2 emissions, energy consumption, and the reliance on various energy sources like coal, hydro, natural gas, nuclear, oil, and renewables. Metrics also cover renewable electricity production, energy efficiency, and overall energy use. It provides **demographic and spatial data**, such as population density, total population, and land area. From this dataset, only those rows containing data about EU's members **from 2010 to 2020** were selected.

2.2 Description of the datasets 'Invested in renewables - The only way forward'

The European Investment Bank essay 'Invested in renewables - The only way forward', which can be read at the following link: https://www.eib.org/en/essays/europe-energy-transition-renewable, has made available two datasets:

- **Investment in the energy transition ($ billion), by region:** it considers renewable energy, energy storage, power networks, electrified transport, clean shipping and industry, carbon capture technologies, hydrogen and nuclear energy, giving a complete picture of the evolving energy landscape.
- **Investment in renewable energy ($ billion), by region:** it considers any renewable source, such as solar, wind and hydroelectric.

These datasets present the investments in energy transition and renewable energy of different countries and regions **from 2014 to 2023** done by European

Investment Bank. The financial institution sustains both public and private initiatives. Due to the lack of data, investments during the years from 2010 to 2014 are not reported in this project.

3 Visual choices

3.1 Palette

The main colors used in the project are two contrasting colors: **green** (#0c6b37), associated with renewable energy, and **red** (#bc2023), linked to fossil fuels and unsustainability.

Picture 1. Color palette and chromatic distribution of the dashboard.

The choice of these two opposite colors is based on **cultural, psychological and practical reasons**. **Green** is strongly connected to the **environment** and is used in political and social movements that advocate for sustainability and green energy. On the other hand, **red** is associated with heat and combustion, in particular the burning of **fossil fuels**, such as coal, oil and natural gas, and with the danger that comes from these harmful energy sources.

This color scheme clearly **separates** fossil fuels from renewable sources, emphasizing the need for a shift from the former to the latter. Furthermore, it makes the charts more **intuitive** and **interpretable**.

To **balance** the color palette, different shades of **gray** (primarily #efefef) are used as **background**, making the dashboard more elegant.

3.2 Fonts

Two fonts are utilized in the dashboard: **Ubuntu** for the section's titles and **Open Sans** for the text and graph's titles; both of them belong to sans-serif family, which guarantee stylistic coherence and legibility.

Ubuntu title example

It emphasizes the title of each section, making them distinguishable and modern thanks to its soft curves.

Open Sans text example

It is one of the most recognized fonts and its popularity transmits reliability and professionalism. Its sober design guarantees legibility for different dimensions.

4 Dashboard modules

The dashboard is divided into three sections, each one regarding a specific aspect of environmental and energy trends.

4.1 Evolution of CO_2 in the EU: 2010 – 2020

The first section shows the **evolution of carbon dioxide emissions**, the main greenhouse gas from burning fossil fuels, during the second decade of the 2000s. The reduction in emissions is partly due to improved energy efficiency, driven by policies like the Energy Union, which promote cleaner energy and better energy management. This trend presents a strong opportunity for investment in energy transition: energy optimization enables a direct reduction of pollution and energy prices, with a positive impact on the environment and the citizens.

4.1.1 CO_2 emissions reduction in EU (%): 2010 – 2020

4.1.1.1 Preprocessing of the dataset 'Sustainable Energy Investment Forecast Dataset'

To **compare CO_2 emissions** from **2010** to **2020**, from the dataset only rows relative to EU's members were selected for the column 'CO2 emissions (kt)', which recorded the emissions of carbon dioxide in kilotons for each country every year.

The variable was normalized in 0 – 100 range to easily compare each country, without the problems that derive from different orders of magnitude.

4.1.1.2 Visualization description

Picture 2. Choropleth map representing CO_2 emissions reduction in EU (%): 2010 – 2020.

The visualization shows the different **magnitude of CO_2 emissions**, spanning from 0% if the reduction was null to 100% if the country reached net zero, across EU's countries during 2010-2020.

The chromatic scale has different shades of green, based on the intensity of the reduction, which spans **from 6,5 to 61,64** since extreme values were not observed.

4.1.1.3 Key insights

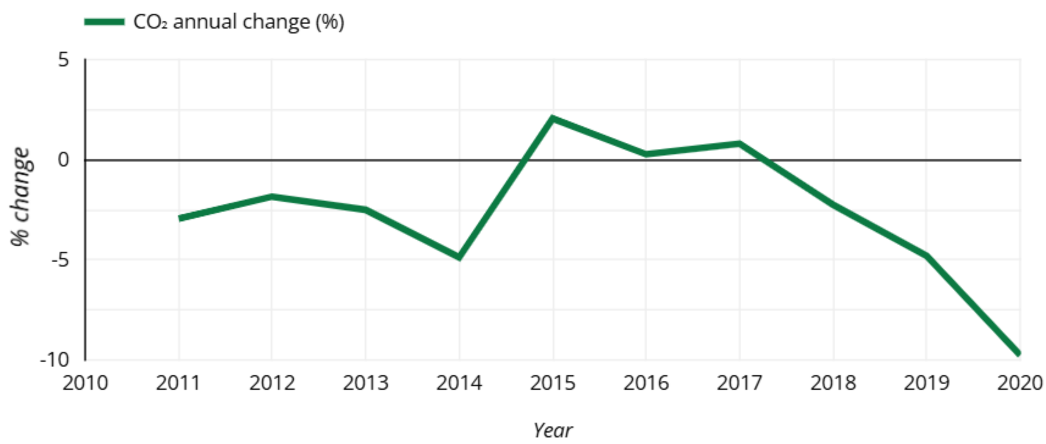
Over the past decade, the **leading countries** in emissions reduction are the **Northern** ones, especially **Estonia** that reached a decrease of **61,64%**; **Greece** stands out as the only non-Northern state that consistently dropped its emissions, reducing them by **41,76%.** On the other hand, the country that showed the smallest progress was **Hungary**, with just **6,5%**. Most EU **countries** saw decreases ranging **from 10% to 30%**, highlighting varying opportunities for impact and growth in the renewables sector across the region. This landscape carries out the effects of policies such as the **Paris Agreements** and **Sustainable Development Goals (SDG)**.

4.1.2 Annual Change of EU's total CO_2 emissions: 2010 - 2020

4.1.2.1 Preprocessing of the dataset 'Sustainable Energy Investment Forecast Dataset'

From the dataset it was selected only the column '**CO2 emissions (kt)**' and it was computed a variable that is the difference between every year, **from 2010 to 2020**, of CO_2 emissions in a **0 – 100 range**, to **compare each year with the previous one**. The calculation has been made for all the European Union, since the data for each country has been shown in the first graph.

4.1.2.2 Visualization description



Picture 3. Line chart representing Annual Change of EU's total CO_2 emissions from 2010 to 2020.

The line chart shows the **temporal dimensionality** that was not predominant in the first one, consider a year-by-year granularity. The x-axis represents the years, while the y-axis the **percentage of the annual change in emissions in all EU**, and the 0% annual change is marked through a line parallel to the x-axis. The difference between 2010 and 2009 is not shown, since 2009 is not considered in the period analyzed.

4.1.2.3 Key insights

From 2015 to 2020, emissions saw a **significant shift**, ranging from a 2,06% increase in 2015 (compared to 2014) to a sharp **-9,76% drop in 2020** (compared to 2019). Before 2014, emissions generally declined between -2% and -5%. However, from 2014 to 2017, emissions increased, particularly in 2014–2015, with a notable 7% rise. This surge was driven by an economic upturn that boosted oil consumption, especially in the road transport sector, underscoring Europe's heavy reliance on oil.

Even though European Council decisions have been crucial in decarbonization, these trends highlight the urgency of implementing **policies** to reduce emissions while supporting economic growth. The sharp -9,76% drop in emissions between 2019 and 2020 was largely due to the **COVID-19 lockdowns**, which curtailed road transport, that is the main source of pollution.

4.1.3 CO_2 emissions and Energy Use per capita in EU: 2010 – 2020

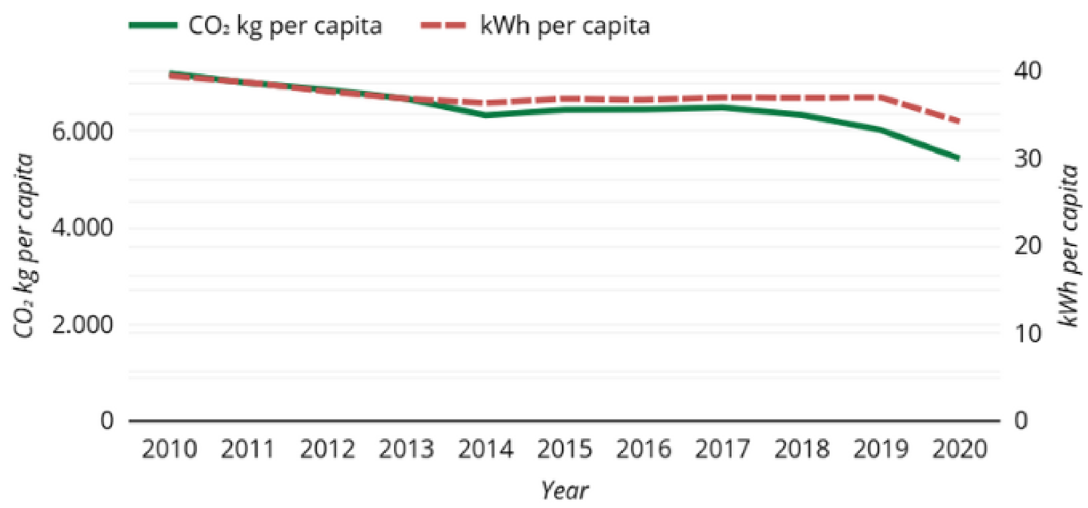
4.1.3.1 Preprocessing of the dataset ‘Sustainable Energy Investment Forecast Dataset’

To **compare** the **evolution of CO2 emissions and energy use** of a European Union **citizen** during the period **2010 - 2020**, the following columns were selected: ‘Energy use (kg of oil equivalent per capita)’, ‘CO2 emissions (kt)’ and ‘Population, total’. For each year, it was computed the **average of the variables** of all states.

The unit of measurement with which emissions were measured is the total kilotons in one year. Since per capita emissions are measured in kilograms, the column ‘CO2 emissions (kt)’ was multiplied by 10^6. This was divided by ‘Population, total’ to compute the CO_2 emissions per capita (kg).

The unit of measurement of the column 'Energy use (kg of oil equivalent per capita)' was converted from kg of oil equivalent to kilowatt-hours, multiplying it by 11,63.

4.1.3.2 Visualization description



Picture 4. Double line chart representing CO_2 emissions and Energy Use per capita in EU during 2010 – 2020.

The graph **compares** the **evolution of the emissions in kilograms of CO_2 per capita**, on the left y-axis, and the **energy use per capita computed in kWh**, on the right y-axis. The former is represented through the green line, just like in the plot 'Annual Change of EU's total CO_2 emissions: 2010 - 2020', the latter through a red dotted line: the color chosen and the dots make the lines distinguishable from one another.

4.1.3.3 Key insights

Emissions per capita **constantly declined** from 7202,96 in 2010 to 5439,07 in 2020, reflecting a **lower carbon intensity per unit of energy consumed**.

From 2018 to 2020, the **gap** between emissions and energy use **widened**, thanks to **improved energy efficiency**. This shift was driven by changes in the productive system, supported by EU incentives promoting energy savings and renewable energy. These trends underscore the EU's commitment to sustainable practices, creating favorable conditions for green energy investments.

4.2 Changes in Energy Consumption and Production in the EU: 2010 – 2020

Climatic, political and economic swings changed the European Union's energy consumption and production from 2010 to 2020. Energy demand stabilized from 2016 onwards because of economic recovery, compared to 2015, and it wasn't modified by the pandemic. In particular, the **average European electric power consumption has diminished**, with a **rise in 2016** in **warmer areas** due to **higher temperatures**. Following these necessities, over the decade **renewable energy** consumption and production has consistently grown, **replacing fossil fuels**. These achievements demonstrate EU's commitment to sustainability. The **coordinated approach** to energy management among member states enhances effective **energy transition** and **independence**.

4.2.1 Average Electric Power Consumption in the EU (kWh per capita): 2010 – 2020

4.2.1.1 Preprocessing of the dataset 'Sustainable Energy Investment Forecast Dataset'

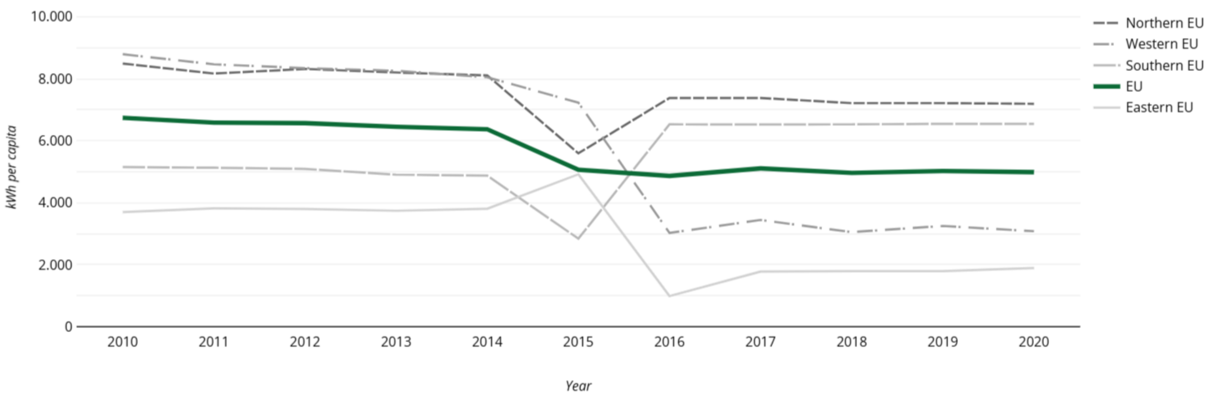
The initial dataset was filtered to include only the rows with European Union countries whose data spans the years 2010 to 2020. The EU was divided into the regions identified by the **United Nations geoscheme**, which divides European countries into the following zones:

- **Northern EU:** Denmark, Estonia, Finland, Latvia, Lithuania, Sweden
- **Southern EU:** Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia, Spain
- **Western EU:** Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands
- **Eastern EU:** Bulgaria, Czechia, Hungary, Poland, Romania, Slovakia

The dataset was grouped by region, calculating the **average of the 'Electric power consumption (kWh per capita)'** variable **for each region by year**, which measures the average annual consumption per person. In particular, energy consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. It contains a dimension of energy efficiency.

The average per capita consumption for the **entire European Union from 2010 to 2020** was also calculated. The result was a dataset with these columns: Year, EU, Southern EU, Northern EU, Eastern EU, Western EU. This made it possible to **compare** the evolution of per capita energy consumption by region rather than by individual countries. The countries within these clusters share similar climatic and economic conditions, allowing an evaluation of consumption in relation to average temperatures.

4.2.1.2 Visualization description



Picture 5. Multiple line graph of the evolution of average electric power consumption in the EU (kWh per capita) from 2010 to 2020.

The **multiple line graph** studies the evolution of average electricity consumption per capita (on the y-axis), calculated in annual kilowatt hours, from 2010 to 2020 (on the x-axis). It shows the average consumption in Europe (in green) compared with the average consumption in the four European areas (Northern Europe, Southern Europe, Western Europe and Eastern Europe). Each area has a different shade of grey with a different line, in order to emphasize the EU and to distinguish one region from another.

4.2.1.3 Key insights

The visualization shows a **decline in average electric power consumption** across the European Union, following the reduction in average energy use, as previously detailed in ‘CO_2 Emissions and Energy Use per Capita in the EU during

2010–2020.' Overall, **from 2016 to 2020, energy consumption stabilized**, sustained by steady electricity demand. While the 2020 lockdowns significantly disrupted energy demand in some sectors, this was balanced by increased household consumption, resulting in stable overall energy use.

The **decline wasn't uniform**: per capita energy use began decreasing in 2014, and between 2014 and 2015, electricity consumption fell across most of the European Union, except in Southern Europe. This reduction was influenced by varying consumption patterns, improved efficiency, the economic crisis and milder winters, particularly in Eastern and Western Europe.

The average power consumption in **Southern Europe increased** from 2015 to 2016 before stabilizing. **Torrid temperatures** from 2016 onwards drove higher energy demand in warmer areas.

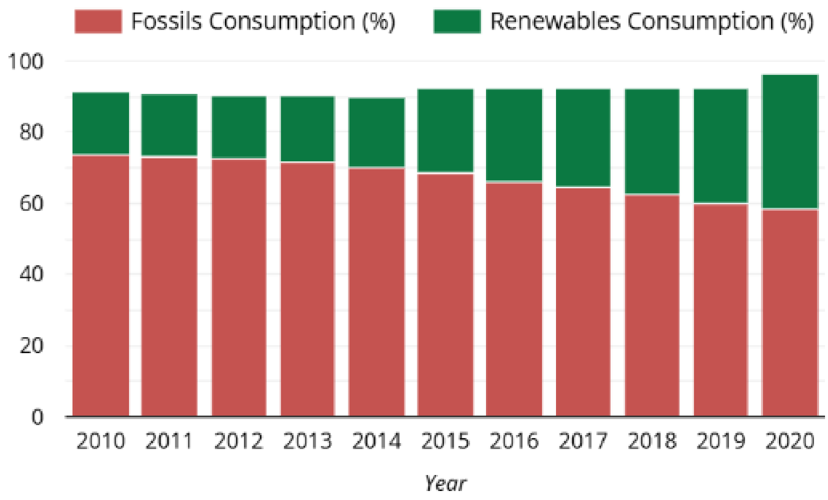
This framework reflects **improved efficiency** in the **electricity grid** and shifts in citizens' habits, driven by the European Council, ensuring **political alignment** among member states.

4.2.2 Renewables vs Fossils Consumption in EU (%): 2010 – 2020

4.2.2.1 Preprocessing of the dataset 'Sustainable Energy Investment Forecast Dataset'

The following variables were considered: '**Renewable energy consumption (% of total final energy consumption)**' and '**Fossil fuel energy consumption (% of total)**'. For each variable, it was calculated the **European average of consumption for each year** of the decade 2010-2020. The aim is to compare the collective changes in energy mix of the two sources within EU, not considering individual country's differences, obtaining a broad overview.

4.2.2.2 Visualization description



Picture 6. Stacked bars chart of renewables and fossils consumption in EU (%) from 2010 to 2020.

To **compare the consumption of fossils and renewables** during the decade it was chosen a stacked bars chart, where the former is the red bars and the latter the green bars. The y-axis spans from 0 to 100, showing all possible values of the consumption in **percentage**. The value does not reach 100% since other consumption sources are not shown, in order to emphasize the comparison between fossils and renewables. The x-axis represents the different years of the decade **from 2010 to 2020**.

4.2.2.3 Key insights

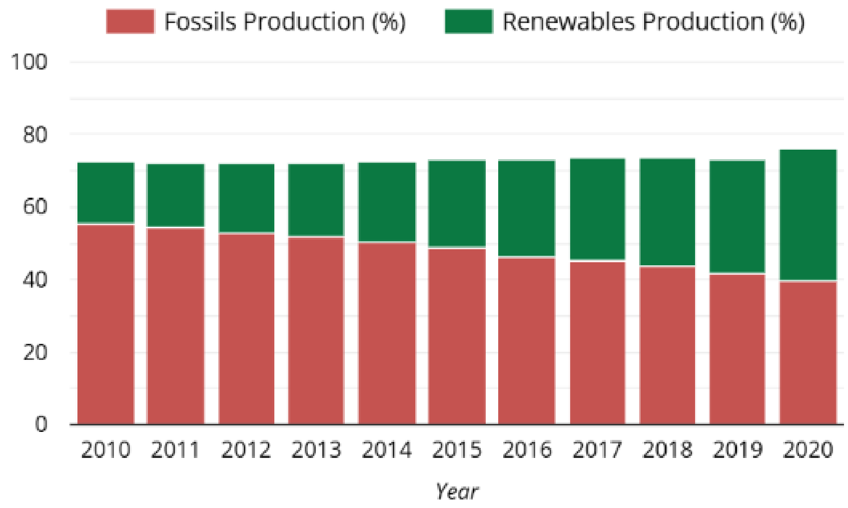
Fossil energy consumption decreased by 15 percentage points, from 73,74% in 2010 to 58,3% in 2020, leaving space for a remarkable **increase of 20% in renewable energy consumption**, which rose from 17,53% in 2010 to 38,2%. This reflects a significant and ongoing transformation in the European energy mix. The EU's policies and the growing demand for sustainable energy solutions created the perfect context for the expansion of the renewable sector.

4.2.3 Renewables vs Fossils Production in EU (%): 2010 – 2020

4.2.3.1 Preprocessing of the dataset 'Sustainable Energy Investment Forecast Dataset'

The rows selected from the dataset contained only the data on EU's countries from 2010 to 2020 for the variables '**Energy production from renewable sources (% of total)**' and '**Energy production from oil, gas, and coal sources (% of total)**'. For the same reasons listed in paragraph 4.3.2, the European percentage average was used.

4.2.3.2 Visualization description



Picture 7. Stacked bars chart of renewables and fossils production in EU (%) from 2010 to 2020.

The chart has the same structure of the one described in the paragraph 4.2.2 and it **compares** the **ratio** of total energy produced in the EU, focusing only on **renewables** and **fossil fuels**, while excluding other sources from the visualization. It shows that, over the decade, 75% of energy produced in the EU is divided into fossils and renewables.

4.2.3.3 Key insights

The insight exposes how **fast** the **renewable sector is expanding** and its enormous potential for growth and profitability. Over the decade, the **production of renewable energy doubled**, surging from 17,4% in 2010 to 36,8% in 2020. This noticeable growth replaced the production of fossil fuel, whose share constantly declined by 1,5 percentage points annually, dropping from 55,3% to 39,5%. The consumption of **renewable energy grew** at the same rhythm as its **production**. This goal, achieved through incentives, guarantees **more self-sufficiency** for the European Union, reducing reliance on external and polluting sources, and demonstrates the EU's accelerating energy transition and commitment to sustainability.

4.3 Investment in Sustainable Energy in EU, US and China: 2014 – 2023

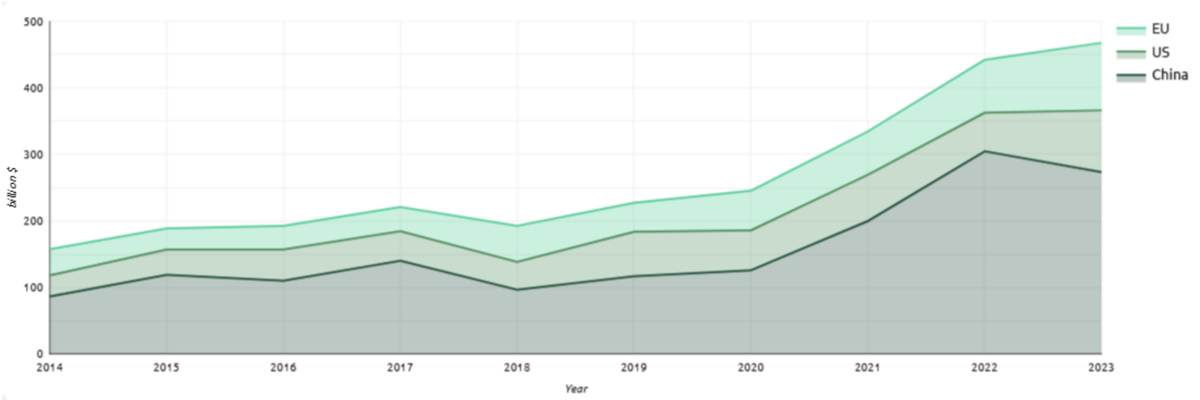
This section focuses on the period that spans **from 2014 to 2023**, a different year range, to underline the importance of the breakage of **war in Ukraine in 2021** and its repercussions on energy market, especially with EU's limited access to natural gas: renewable investment reached their **peak** in **2022**, the year of the presentation of the **REPowerEU**, which planned independency from Russian gas. Only the three major statal investors are shown, of which **China** is the **leader** both in Renewable Energy and Energy Transition investment, followed by EU. The **EU**'s investment in green energy and energy transition **increased faster** than its competitors, thanks to economic incentives, policies and market expansion. These trends set the stage for a more sustainable future, whose leading role is clean energy.

4.3.1 Investment in Renewable Energy in EU, US and China: 2014 – 2023

4.3.1.1 Preprocessing of the dataset 'Invested in renewables - The only way forward'

From the essay 'Invested in renewables - The only way forward' the dataset selected was '**Investment in renewable energy ($ billion), by region'**. To highlight the main competitors, only the three major statal investors are considered, which are **European Union, United States and China**. The unit of measure is the 2023 U.S. dollar, which is the common currency in investment.

4.3.1.2 Visualization description



Picture 8. Stacked area of investment in renewable energy in EU, US and China from 2014 to 2023.

The stacked area makes it possible to compare the growth of European, American and Chinese investment during the selected period, each one with a different shade of green to distinguish one from another. On the x-axis, years **from 2014 to 2023** are marked. The y-axis highlights the **investment in billions of dollars from 0 to 500.**

4.3.1.3 Key insights

The graph shows a **consistent increase** across the EU, US, and China, especially from 2020: to stimulate energy sector, one of the most struck by the pandemic, governments saw an opportunity in renewables. Furthermore, the complex geopolitical context in Ukraine upset global energy policies.

China confirmed itself as the **global leader in renewable energy** thanks to its massive investment in research and development and its ambitious goals to increase installed capacity of renewable energy. In **2020 half of the global investment** in renewable energy was from **China**, with **273 billion dollars**. Its **growth** has **slowed down from 2022** because of **inflation** regarding raw materials.

The **EU** shows the **largest growth**, reflecting the political decisions of the European Council. The EU depended mostly on Russian gas, but the outbreak of **Russia-Ukraine war in 2014 and 2021** has increased energy prices and accelerated the need for trustworthy and clean energy. The **EU's investment** in green energy **increased by 132% from 2019 to 2023** and, over the period, its investment has nearly tripled, especially in solar energy. The European market presents itself as an interesting choice for **institutional investors**.

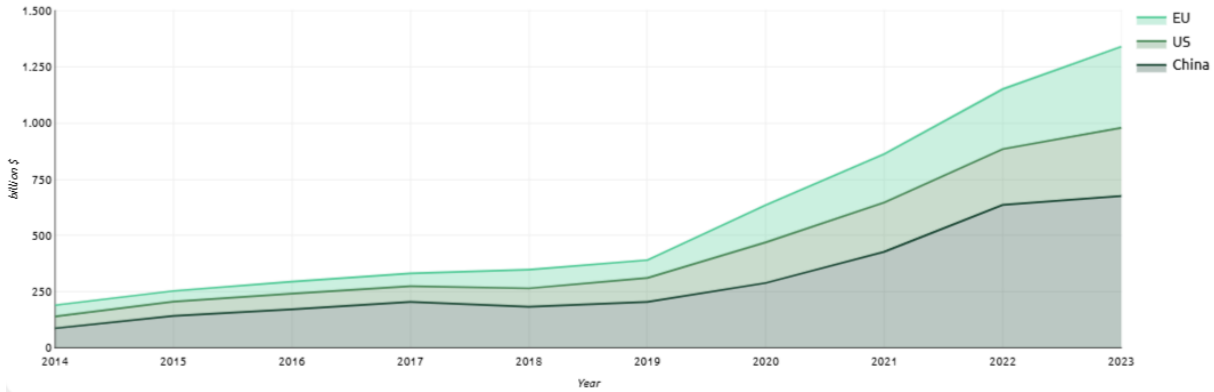
The third main competitor is the **United States**, where the demand of clean energy grew on account of tax incentives, such as solar and wind energy tax credits. The result is that its **investment** in renewables has **tripled from 2014 to 2023.**

4.3.2 Investment in Energy Transition in EU, US and China: 2014 – 2023

4.3.2.1 Preprocessing of the dataset 'Invested in renewables - The only way forward'

The dataset selected from the essay was **'Investment in energy transition ($ billion), by region'**. To focus on the main competitors, the analysis includes only the three largest state-level investors: the **European Union, the United States, and China**. The measurement unit used is the 2023 U.S. dollar, serving as the standard currency for investment analysis.

4.3.2.2 Visualization description



Picture 9. Stacked area of investment in energy transition in EU, US and China from 2014 to 2023.

The stacked area chart allows for a **comparison** of the growth of each **competitor** over the selected period, with each competitor represented by a distinct shade of green for easy differentiation. The x-axis displays the years **from 2014 to 2023**, while the y-axis shows **investment** figures in **billions of dollars**, ranging **from 0 to 1500**.

4.3.2.3 Key insights

Worldwide, **investment in energy transition grew** in the period **from 2014 to 2023** because of an increased **environmental awareness**, which stimulated a series of policies and technological innovations. During the period **from 2019 to 2023** cumulative investment rose linearly, thanks to **strategic collaborations** and **economic stability**. The three main investors, after an initial post-pandemic adjustment, found the energy transition as a push for economic growth. The interest in renewables was a part of this wider framework.

China is the **leader** in investment, reaching **676 billion dollars**. Aside from renewables, China has a great interest into innovative technologies such as energy storage systems and energy efficiency in industry and transportation.

The **EU** is the **second** global investor and is the **fastest growing** one: **from 2019 to 2023** its investment grew by **355%**. The **strategic planification** of policies that aim to transform Europe into the first net zero continent by 2050, alongside the international pressure on sustainability, has given considerable stimula to this emerging market.

United States federal incentives were mostly interested in **infrastructure** for electric mobility and buildings energy **efficiency** and other clean and sustainable technologies and infrastructures.

5 Conclusions

The period **from 2010 to 2020** was characterized by **strong growth** in the **renewable energy** sector, **both in consumption and production**. One of the consequences is the reduction of CO_2, partly thanks to greater **efficiency** in the energy sector. The advent of the energy transition in the EU has led to a 20% increase in renewable energy consumption, while, on the contrary, fossil energy consumption has decreased by as much as 15%. Green energy production has also increased, since it increased from 17,4% to 36,8% of the total energy production.

The **geopolitical** framework, which saw the invasion of Ukraine by Russia, accelerated the transition and showed the **importance** of **energy independence**.

Initiatives such as the European Green Deal and REPowerEU have successfully driven the growth in investments in green energy (132%). The EU is positioned among the **top** three **global** market **investors**, alongside competitors such as **China** and the **United States**; European Union stands out for the fastest growth in investments in renewable energy.

Engaging in energy transition offers EU members the chance to be part of one of the most dynamic and **transformative sectors** of the coming decade.

6 Sources

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- Generative AIs, such as ChatGPT and Perplexity, were used to find sources and as a support to a better writing style and as translators.