Introduction

Climate change is a huge challenge worldwide and has gained more attention in recent. The global cause to stop climate change or at least slow it down often focuses on global warming, like the Paris climate agreement, which legally binds the 196 parties "to limit the temperature increase to 1.5 °C above pre-industrial levels".

Among various other contributors to global warming, burning fossil fuels for energy consumption stands out as a primary factor to this day. When burning fossil fuels, substantial amounts of greenhouse gases are released into the atmosphere, which increase the so-called greenhouse effect, in turn accelerating global warming and climate change. Facing the amount of greenhouse gases produced by the energy sector, many countries — including countries of the European Union (EU) — intensified their efforts to transition towards more sustainable energy sources.

This report aims to explore the aforementioned relationship between energy consumption and net greenhouse gas emissions across countries of the EU, in order to show how they are interconnected. Furthermore, this report is set to discover how this connection is influenced by the share of renewable energy sources in the energy pool of a country. This might help to indicate, how effective the adoption of renewable energy sources is in fighting climate change.

The resulting core questions are:

1. How does the amount of energy consumed influence the net greenhouse gas emissions of European countries?
2. , And how is this influenced by the share of renewables in total energy?

Used Data

This report uses a merged dataset produces by a data pipeline, derived from three data sources, all originating from Eurostat. The resulting dataset provides a comprehensive view of net greenhouse gas emissions, primary energy consumption and the share of renewable energy sources across countries of the EU.

Structure and Meaning of the Dataset

The dataset is structured as a SQLite database containing three tables, each covering one data source from Eurostat. Each table includes the following three columns:

- **geo**: The ALPHA-2 country codes representing each EU country.
- **year**: The year in which the data was recorded.
- **value**: The observed value for the specific metric in each table.

Net Greenhouse Gas Emissions: This table contains the amount of greenhouse gases emitted per person in each country for the specified years. The emissions data is measured in tonnes per capita.

Primary Energy Consumption: This table shows the energy consumption per person in each country, measured in Tonnes of Oil Equivalent (TOE) per capita.

Share of Energy from Renewable Sources: This table covers the proportion of energy consumed, which originates from renewable sources as declared by the EU, highlighting the adoption of renewable energy sources in each country. The data is measured in percentage of the total consumed energy.

Compliance with Data Licenses

All data used in this analysis is sourced from Eurostat and is subject to the Eurostat copyright notice, which allows free re-use of data under obligations.

In order to comply, this report attributes Eurostat as the source of all data. Furthermore, during the processing of the data sources by the pipeline, the source data was cleaned with certain rows and columns being removed for relevance and consistency.

In detail, the following modifications to the source data were performed:

- Table Net Greenhouse Gas Emissions: all rows were removed, which did not cover the unit of measure "Total (Tonnes per capita)"; all rows that covered other source sectors than "Total (excluding memo items, including international aviation)" were removed.
- Table Primary Energy Consumption: all rows were removed, that did not cover the unit of measure "Tonnes of oil equivalent (TOE) per capita".
- Table Share of Energy from Renewable Sources: all rows were removed, that did not cover the topic "Renewable energy sources".
- For all tables all columns except "geo", "TIME_PERIOD" and "OBS_VALUE" were removed.
- For all tables, the headers for "TIME_PERIOD" and "OBS_VALUE" were renamed to "year" and "value" respectively.
- For all tables, all rows were removed that did cover countries, which are not currently part of the 27 EU member states.

Analysis of the Data

Correlation between Energy Consumption and Emissions

Method Used

In order to answer the first question considering the correlation between emissions and energy consumption, the data first had to be prepared: The data on emissions, energy consumption and the share of renewables was extracted from the SQLite database and the datasets were merged on country codes and years to create a unified dataset for analysis. The approach then was to create a scatter plot for visualizing the relationship between energy consumption and the greenhouse gas emissions. The plot includes data points for all countries and all years in order to give an overview over the EU as a whole. The single dots are colored appropriate to a scale. This scale was then included in the plot in the form of a color bar as a legend. In order to make the plot more readable, linear regression was used to create a linear function describing the data. Also, to assess the strength of the two datasets correlation, the Pearson Correlation Coefficient (PCC, r-value) was calculated.

Since the global plot shadows differences between single countries, also plots for all countries were created in order to gain insights into the workings of the relationship on a national level.

Results

The resulting global plot can be seen in fig. 1. The scatter plot backed by the regression line point to a positive correlation between energy consumption and greenhouse gas emissions. Furthermore, the r-value is calculated to be .64, indicating a moderate to strong positive correlation.

Although, when observing plots of single countries, huge differences of the analyzed correlations for different countries arise. Luxembourg shows a very strong PCC of $r = 1$, while Austria has a moderate correlation, with an r-value of 0.56.

Luxembourg represents a positive extreme, whereas another example, Slovenia, represents the opposite extreme, showing no positive correlation with an r-value of -0.46. Slovenia is a notable exception, as it is the only country with a negative correlation.

Overall, the median r-value across all countries is 0.86, which is significantly higher than the PCC for the EU as a whole. This high median value indicates a very strong positive correlation in the median, suggesting that most individual countries exhibit a stronger relationship between energy consumption and greenhouse gas emissions than the aggregated EU data.

Interpretation of the Findings

The PCC of .64 for the whole EU indicates that higher energy consumption is generally associated with increased greenhouse gas emissions at the EU level.

However, the analysis of individual countries presents a more nuanced picture. While Luxembourg demonstrates a perfect positive correlation, suggesting that its emissions are almost entirely driven by energy consumption, other

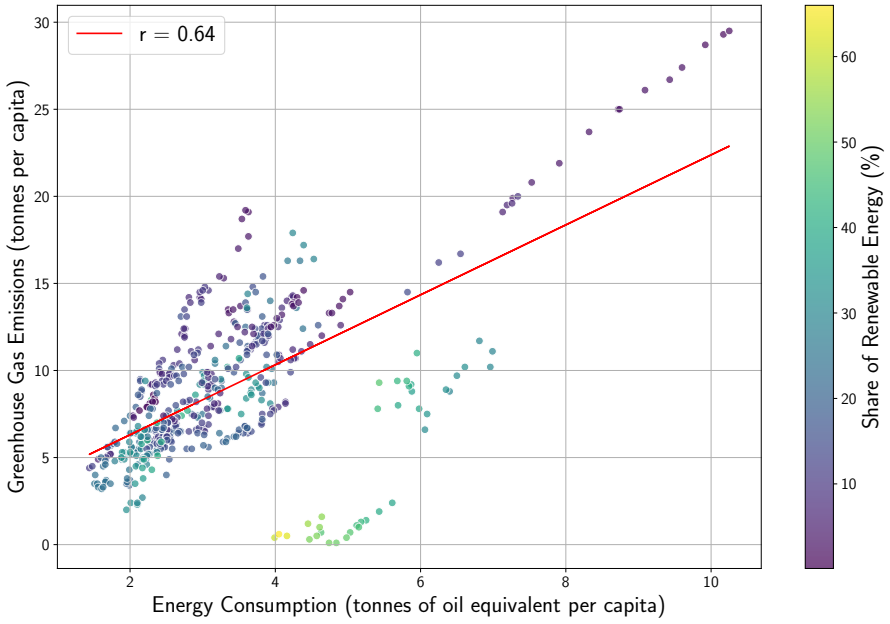

Figure 1: Global Correlation between Energy Consumption and Greenhouse Gas Emissions

countries like Austria show only a moderate correlation. Slovenia stands out as an exception with a negative correlation, indicating other factors significantly influencing its emissions beyond energy consumption.

The median PCC across all countries is 0.86, higher than the EU-wide correlation. This disparity underscores the importance of considering national contexts and policies when analyzing environmental impacts.

Correlation between Emissions and the Share of Renewables

Secondly the report analyzes the follow-up-question considering the correlation between the share of renewable energy sources and the greenhouse gas emissions.

Method Used

Like with the first question, all datasets had to be extracted from the SQLite database and were merged on the country codes and years, resulting in a unified dataset for analysis.

The method for answering the question is also strongly influenced by the first question's method. A scatter plot to visualize the relationship between the share of renewable energy and greenhouse gas emissions was created. The plot includes data points for all years and countries of the EU. Each data point's color represents the level of energy consumption per capita, which is indicated by a color bar included as a legend in the plot.

Also, a trend line was generated for the plot using linear regression and the PCC was calculated for the EU as a whole. Furthermore, the PCC was calculated for all single countries in order to assess the median of the countries PCC, as it proved to be rather informative in analyzing the first question.

Results

The resulting global plot in fig. 2 indicates a significant negative correlation between the share of renewable energy and greenhouse gas emissions. The r-value is calculated to be -.54, suggesting a moderate to strong negative correlation. This implies that a higher share of renewable energy is generally associated with lower greenhouse gas emissions across the EU.

In regard to the median over all national countries, the correlation becomes even far stronger, with a r-value of -.9. This high median value indicates that most individual countries exhibit a very strong negative correlation, suggesting that an increased share of renewable energy is typically associated with substantial reductions in greenhouse gas emissions.

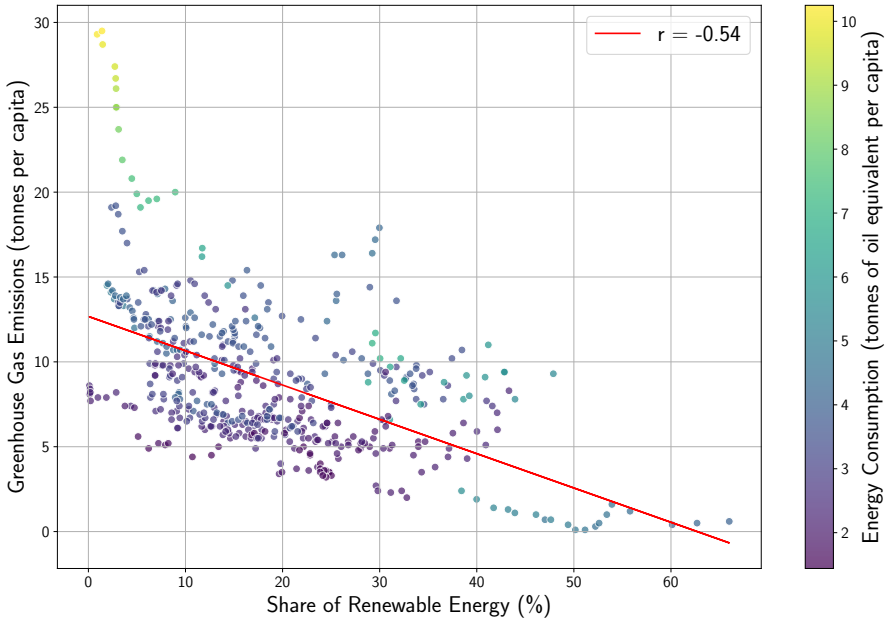

Figure 2: Global Correlation between Share of Renewable Energy and Greenhouse Gas Emissions

Interpretation of the Findings

The analysis of the relationship between the share of renewable energy and greenhouse gas emissions indicates a significant negative correlation. This suggests that increasing the share of renewable energy in the energy mix is generally associated with a reduction in greenhouse gas emissions at the EU level.

When examining individual countries, the median PCC is even stronger at -.9. This high median value implies that most countries experience substantial reductions in greenhouse gas emissions as they increase their share of renewable energy.

Conclusions

How does the amount of energy consumed influence the net greenhouse gas emissions of European countries?

The analysis strongly indicates, that higher energy consumption leads to higher greenhouse gas emissions. To what extent this effect can be observed differs between countries, though overall the correlation is very strong.

And how is this influenced by the share of renewables in total energy?

The significant negative correlation between share of renewable energy sources and emissions strongly indicates, that emissions are also strongly dependent on the burning of fossil fuels. This suggests that most countries will face substantial emission reductions as they increase their renewable energy share.

Critical Reflection

The questions were answered effectively, showing that higher energy consumption tends to increase emissions, while a higher share of renewables tends to decrease emissions. However, limitations include:

1. Data Accuracy: Results depend on the quality of the data used.
2. National Variations: Further research is needed to explore factors driving national differences.
3. Causality: The analysis shows correlation, not causation.
4. Temporal Dynamics: Aggregated data may hide trends over time.
5. External Influences: Factors like technological advances and global policies were not considered.