



Friedrich-Alexander-Universität  
Erlangen-Nürnberg

# Correlation Between Temperature Increase and Energy Consumption In European Countries

Dennis Mustafić

Matriculation Number: 233302080

## Final Report

Methods of Advanced Data Engineering

Research Questions:

1. Has there been a temperature increase in European countries since the 2000s?
2. How has energy consumption changed since the beginning of the 2000s?
3. **Main question:** does a potential temperature increase correlate with energy consumption of Europe?

# 1. Introduction and Motivation

Climate change is a pressing global issue with significant implications for environmental, economic, and social systems. In Europe, rising temperatures have raised concerns about their potential impact on energy consumption patterns. This report aims to investigate whether there has been a noticeable increase in temperatures in European countries since the 2000s and how energy consumption has changed over this period. Understanding these trends is essential to address the main question: Does a potential temperature increase correlate with energy consumption in Europe?

## 2. Data

The dataset used for this analysis contains several key values: surface temperature changes in degrees (`CHANGE_INDICATOR`), tons of oil equivalent per thousand euros of GDP (`MTOE`), and tons of oil equivalent per capita (`TOE_HAB`). The change indicator measures temperature change relative to a baseline climatology corresponding to the period from 1951 to 1980. `MTOE` provides insight into energy efficiency relative to economic output, while `TOE_HAB` indicates the energy consumption per individual in each country. The dataset covers 32 countries and comprises a total of 736 measurements, focusing on the years from 2000 to 2022. Table 1 showcases the data structure in Appendix A. Some countries were removed during the aggregation and data imputation process, which should be understood as one of the main limitations. Further analysis is available in `data-report.pdf`.

## 3. Analysis

### 3.1. Temperature Change

To analyze temperature changes, the change indicator over the years in average for each country is displayed in Figure 1. The data indicates

that 2007 was an especially hot year compared to surrounding years. A significant temperature increase starts to become evident from 2014 onwards, with a notable rise by the end of 2022.

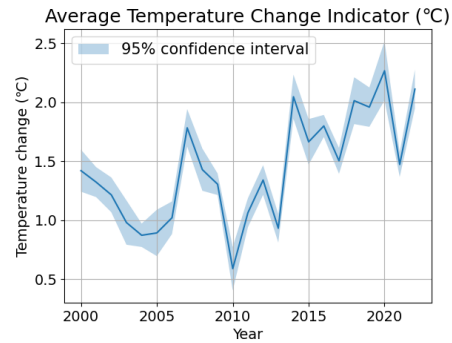


Figure 1: Annual temperature change in degrees Celsius averaged over all countries.

A regional analysis (temperature changes averaged for each country over the whole timespan) reveals that Eastern Scandinavia, and the Baltic countries experienced the highest average surface temperature increases.

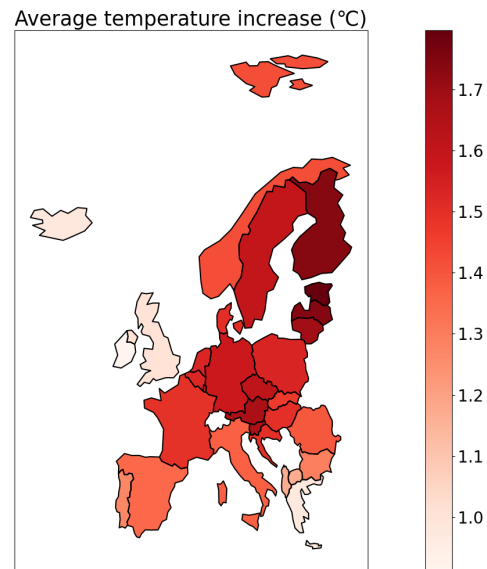


Figure 2: Temperature changes in degree Celsius averaged for each country from 2000 to 2022.

### 3.2. Energy Consumption

Energy consumption analysis in this report focuses on two key metrics: MTOE and TOE\_HAB. These metrics provide a comprehensive understanding of energy efficiency and per capita consumption, essential for assessing energy use relative to economic output and population. Figure 3 visualizes these metrics averaged for all countries, with the left axis representing MTOE (blue) and the right axis representing TOE\_HAB (red). Both graphs exhibit similar characteristics, initially rising until 2007 and subsequently declining. This trend suggests that while energy consumption increased steadily up to 2007, it has been on a decline since then.

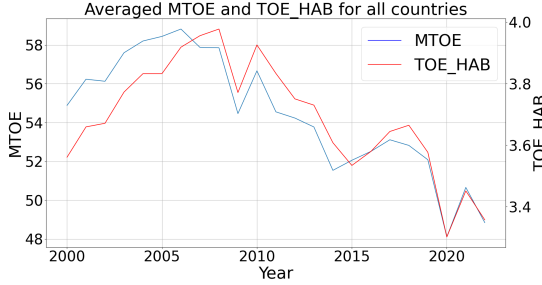


Figure 3: Twin plot showing the country averaged MTOE and TOE\_HAB.

### 3.3. Correlation Between Temperature Increases and Energy Consumption

The main question is whether there is any correlation between temperature increases and energy consumption. The analysis indicates that while surface temperatures have increased, energy consumption has declined since 2007, as shown in Figures 1 and 3. Figure 4 of average temperature increases versus energy consumption, averaged over the years for each country, reveals scattered points. In this twin plot, the blue dots represent MTOE (with the corresponding scale on the left), while the red dots represent TOE\_HAB (with the scale on the right). The scattered points exhibit no strong visible trend.

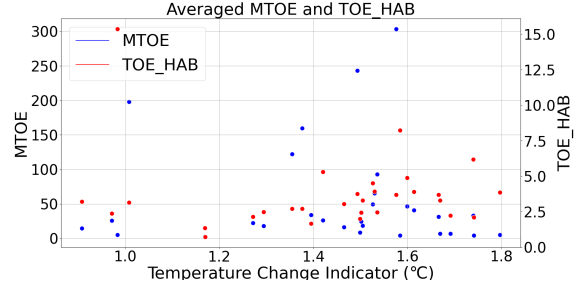


Figure 4: Twin scatter plot of average temperature increases versus average energy consumption (MTOE and TOE\_HAB) for each country for the whole time span.

To account for outliers, the Spearman Correlation was used for the correlation calculation. The results in Figure 5 show that MTOE has a correlation close to zero (0.00021), and the same holds for TOE\_HAB (0.011), suggesting that energy consumption is not correlated with temperature increases.

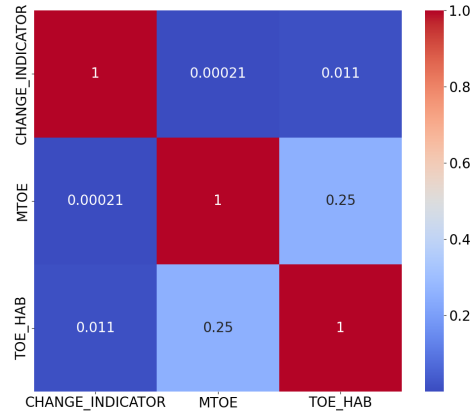


Figure 5: Spearman correlation averaged over the years for each country.

## 4. Conclusion

The analysis indicates that while there has been a notable increase in surface temperatures in European countries since the 2000s, this temperature increase does not correlate with changes in energy consumption. The observed trends in energy consumption suggest a rise until 2007, followed by a decline, which does not align with the steady increase in temperatures. The calculated correlation values further support the conclusion that there is no significant relation between temperature increases and energy consumption in Europe.

The question of whether temperature increase correlates with energy consumption could not be answered unequivocally. Further research with more data might provide additional insights into this complex relationship. Potential limitations include the exclusion of some countries during data aggregation and imputation processes, and the need for more granular data to capture finer trends and anomalies.

## Licenses and Distribution

The dataset used in this analysis is originally based on two datasets, each governed by different open licenses: Creative Commons Zero (CC0) and Open Data License. To ensure compliance with these terms, specific actions were taken. For the CC0 dataset, which allows unrestricted use and distribution, proper attribution to the original authors and sources [1] was provided in `data-report.pdf`. For the Open Data License [2] dataset, a clear statement of the data’s origin and any modifications made was also included in `data-report.pdf`. Additionally, any redistribution of the data retains the original license terms, allowing others to freely use, modify, and distribute the data under the same conditions. Detailed information on the data sources and their respective licenses can be found in `data-report.pdf`. By following these guidelines, the legal and ethical stan-

dards associated with the data’s use and distribution have been respected.

## References

- [1] Creative Commons. (2024). Retrieved from <https://creativecommons.org/public-domain/cc0/>; Last accessed on July 02, 2024.
- [2] Data Europa. (2024). Open data licensing. Retrieved from <https://data.europa.eu/en/academy/open-data-licensing>; Last accessed on July 02, 2024.

## A. Data Structure

TIME_PERIOD	ISO2	COUNTRY	CHANGE_INDICATOR	MTOE	TOE_HAB
2000	AL	Albania	1.065	1.8	0.58
2001	AL	Albania	1.400	0.8	0.99
...	...	...	...	...	...

Table 1: Final data structure after executing the pipeline.