CO2 EMISSIONS

A REPORT AND ANALYSIS OF CARBON DIOXIDE EMISSIONS

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1- Introduction

Carbon dioxide, often referred to as CO2, is a greenhouse gas that exists naturally in the Earth's atmosphere. However, human activities like burning fossil fuels and deforestation have caused a rapid increase in CO2 levels over the years, leading to a rise in global temperatures.

For this reason, there is an urgent global need to reduce CO2 emissions. It is crucial for the entire world to work together and take immediate action to reduce CO2 emissions.

The following report presents an analysis for answering three formulated questions regarding the same context of CO2 emissions:

- What is the biggest predictor of a large CO2 output per capita of a country?
- Which countries are making the biggest strides in decreasing CO2 output?
- Which non-fossil fuel energy technology will have the best price in the future?

To address each question, I will use data analysis techniques based on the collected datasets to find the answers.

Throughout the report, the collected data undergoes review, recalculation, cleaning, and visualisation. Detailed explanations of the data and visualisations can be found on relevant pages. To provide a clear picture of the final results tables and figures are provided.

Finally, in Chapter , I will wrap everything up with a summary of the main conclusions.

2- Data collection

For this analysis, all the datasets has been collected from the source, "Our World in Data" (https://ourworldindata.org/). The website provides an extensive and reliable collection of diverse datasets related to various global

Table 01: Correlation Coefficients between CO2 Emission Factors and CO2

Factors	Correlation Coefficient
Fossil fuels per capita (kWh)	0.9202683187701572
Nuclear per capita (kWh - equivalent)	0.07482180439118728
Renewables per capita (kWh - equivalent)	0.05055997792126655
Annual CO_2 emissions from land-use change per capita	-0.06178647674293554
Meat (kg per capita)	0.4771359542051424
Milk (kg per capita)	0.4094518174139367

Table 01: Correlation Coefficients between CO2 Emission Factors and CO2

Agricultural land	0.027562428922279513
GDP per capita	0.6089513517029637
Population (historical estimates)	-0.010171526362744468
Primary energy consumption per GDP (kWh/$)	0.40158041236279635
Transport (per capita) (CAIT, 2020)	0.5605292917700218
Per capita international aviation CO2	0.4500473684637964
battery_electric_number	-0.04225554103044998
plugin_hybrid_number	-0.05478219531855289
full_mild_hybrid_number	-0.12789307336357916
petrol_number	0.5125000489930885
diesel_gas_number	0.7043913870484125
total_cars	0.7753263573506987
GNI per capita, PPP (constant 2017 international $)	0.8160070436095466
Gini coefficient	-0.43334401279178925

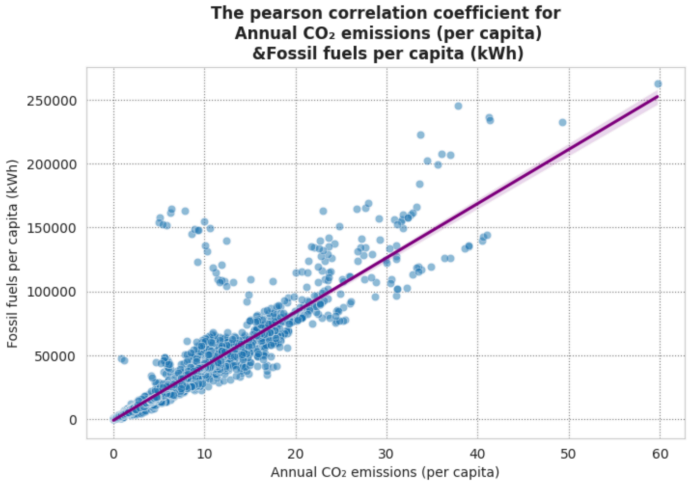
issues, including environmental and climate-related data.The data collection process involved navigating through the website's data repository to find the relevant datasets related to asked questions on CO2 emissions.

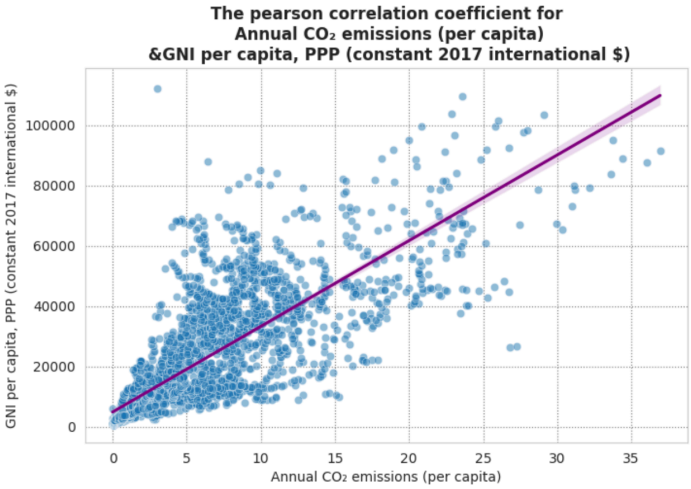
3. Biggest predictors of CO2

What is the biggest predictor of a large CO2 output per capita of a country?

To find the answer for this question, an in-depth analysis was conducted to study the factors influencing CO2 emissions. Several key contributors were identified:

- Energy - fossil fuel and renewables
- Changes in Land Use
- Food diet, like Meat and Dairy
- Agriculture
- GDP and Population
- Transportation, Aviation, and Shipping
- Gross National Income (GNI) and Gini Index





To find the connections between these factors and CO2 emissions, the Pearson correlations has been calculated and visualised with scatterplots.

The results of this investigation are clearly illustrated in tables and figures. These visual representations provide valuable insights into the relationships between each factor and CO2 emissions.

3.A. Results

The table.01 displays the correlation coefficients between various factors related to CO2 emissions and the actual CO2 emissions. The positive correlation coefficients indicate that these factors are positively associated with CO2 emissions. For instance, factors such as *fossil fuel consumption*, *GNI per capita*, and *GDP* have strong positive correlations with CO2 emissions, implying their significant impact on greenhouse gas emissions.

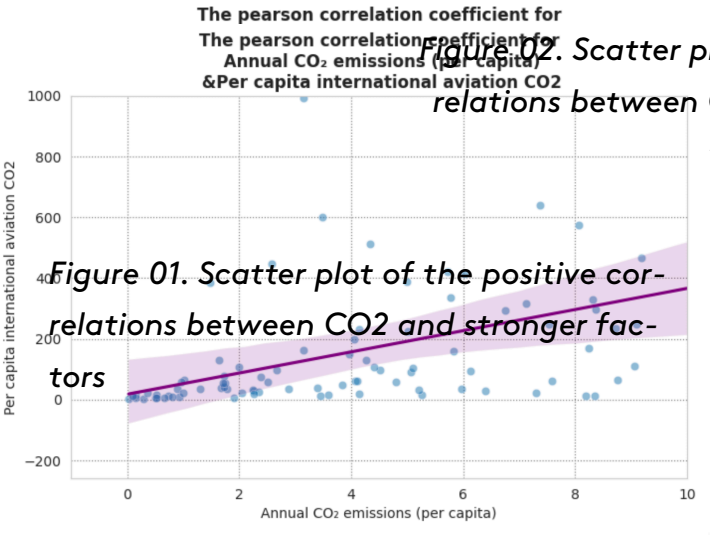


Figure 01. Scatter plot of the positive correlations between CO2 and stronger factors

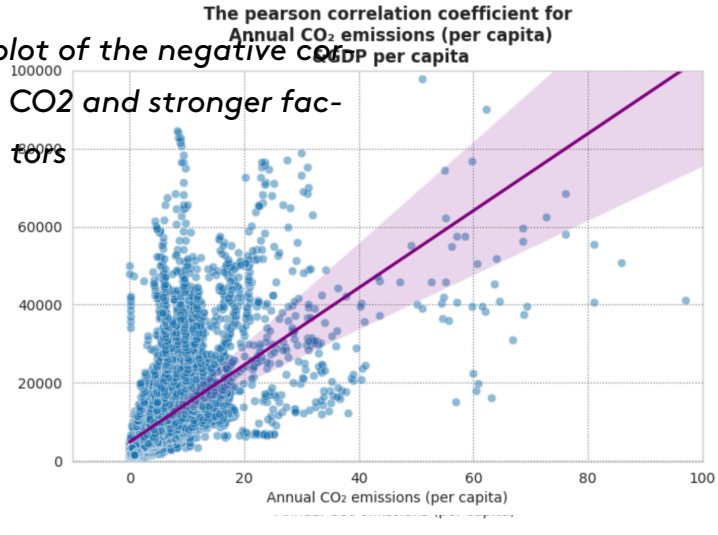
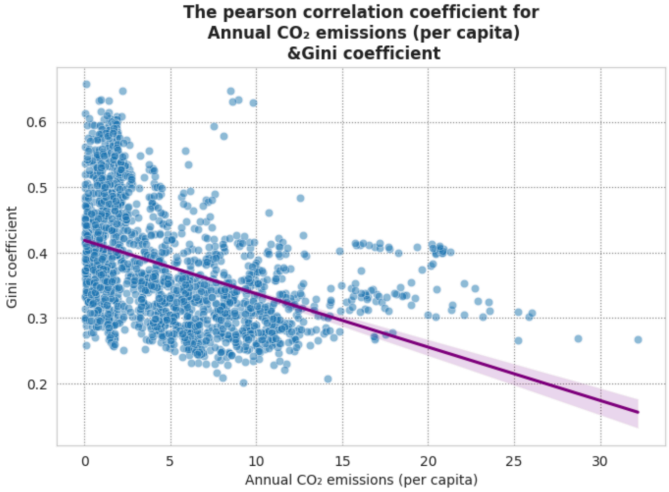
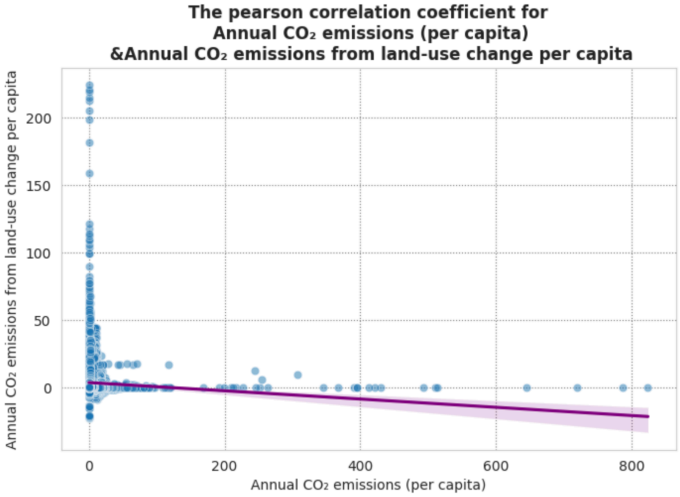
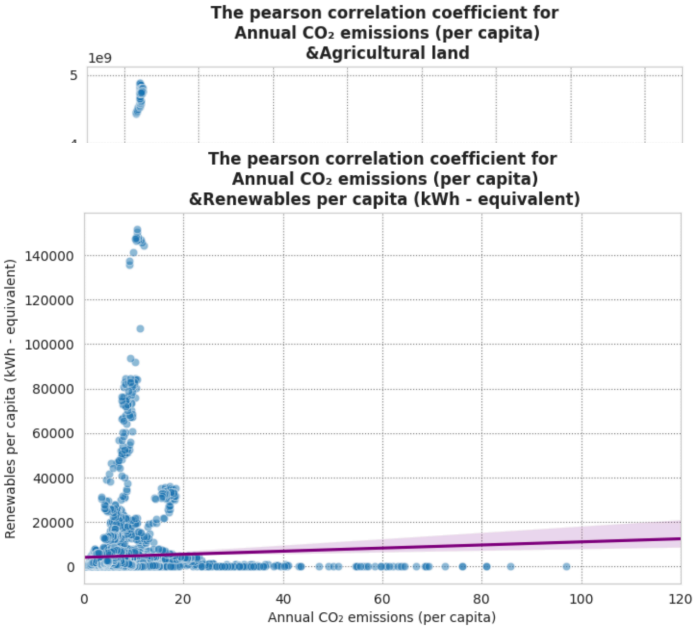


Figure 02. Scatter plot of the negative correlations between CO2 and stronger factors


The pearson correlation coefficient for
Annual CO₂ emissions (per capita)
&Gini coefficient
Gini coefficient
Annual CO₂ emissions (per capita)


The pearson correlation coefficient for
Annual CO₂ emissions (per capita)
&Annual CO₂ emissions from land-use change per capita
Annual CO₂ emissions from land-use change per capita
Annual CO₂ emissions (per capita)


The pearson correlation coefficient for
Annual CO₂ emissions (per capita)
&Agricultural land
1e9
The pearson correlation coefficient for
Annual CO₂ emissions (per capita)
&Renewables per capita (kWh - equivalent)
Renewables per capita (kWh - equivalent)
Annual CO₂ emissions (per capita)

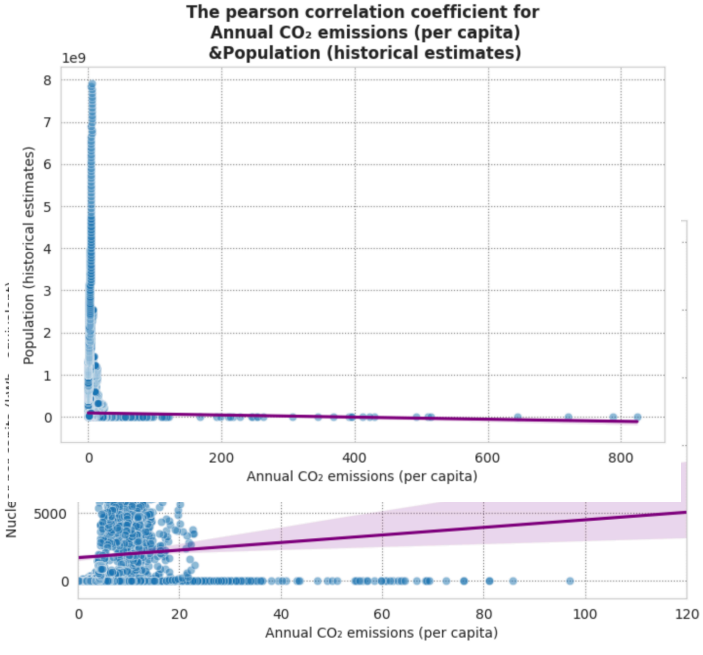

The pearson correlation coefficient for
Annual CO₂ emissions (per capita)
&Population (historical estimates)
1e9
Population (historical estimates)
Annual CO₂ emissions (per capita)
Annual CO₂ emissions (per capita)

Table 02: Top Contributors to CO2 Emissions (in descending order)

Factor	Correlation Coefficient
Fossil fuels per capita (kWh)	0.9202683187701572
GNI per capita, PPP	0.8160070436095466
GDP per capita	0.6089513517029637
Transport per capita	0.5605292917700218
Food - Meat (kg per capita)	0.4771359542051424
International aviation per capita	0.4500473684637964
Food - Milk (kg per capita)	0.4094518174139367
Primary energy consumption per GDP (kWh/$)	0.40158041236279635
Nuclear per capita (kWh - equivalent)	0.07482180439118728
Renewables per capita (kWh - equivalent)	0.05055997792126655

Figure 01 illustrates a series of scatter plots with linear regression lines, showing positive correlations between CO2 emissions and various factors. These plots reveal that as the values of these factors increase, CO2 emissions also tend to rise. A steeper regression line indicates a stronger positive relationship, while a flatter line suggests a weaker association.

Figure 02, on the other hand, shows scatter plots and linear regression lines to highlight negative correlations between CO2 emissions and specific factors. In these plots, as the values of the factors increase, CO2 emissions tend to decrease. The closeness of data points to the regression line indicates the strength of the negative correlation, with steeper lines implying a stronger association. These negative relationships offer valuable insights for promoting environmentally friendly practices and working towards a greener future.

3.B. Conclusion

Based on the analysis, the highest emissions are primarily related to fossil fuel consumption, economic indicators such as Gross National Income (GNI) and Gross Domestic Product (GDP), and transportation activities.

The top 5 factors that have the most impact on producing CO2 emissions in the world are:

1. Fossil fuels
2. GNI per capita
3. GDP per capita
4. Transport
5. Meat consumption

These factors are closely associated with higher CO2 emissions, as expected. Cars, industrial activities, reliance on fossil fuels, and higher income levels can lead to increased CO2 emissions. It is essential to shift to sustainable practices, transition to renewable energy sources, and implement efficient transportation and industrial strategies to ensure better future for our planet.

Answer : What is the biggest predictor of a large CO2 output per capita of a country? **Fossil fuels**

4. Biggest strides in decreasing CO2

2- Which countries are making the biggest strides in decreasing CO2 output?

To address the question of identifying the biggest strides in decreasing CO2 output, data from Our World in Data has been used. Our primary metric was CO2 emissions per capita, which allows to compare countries' CO2 output in proportion to their population size.

To ensure the relevance of analysis and consider the dynamic nature of environmental issues and CO2 emissions, the focus was on the data after year 2015.

Calculating the relative change in CO2 emissions over this period of time, can help to identify the countries that have achieved the most reductions in their CO2 output.

4. A. Results

Table 03. Showing the absolute change in CO2 emissions per capita in order

Table 04. Showing the relative change in CO2 emissions per capita in order

Country	absolute_change
Curacao	31.992635
Trinidad and Tobago	7.648799999999998
Brunei	7.489827999999999
Estonia	7.2127065
Mongolia	7.204687

Country	relative_change_%
Curacao	78.34798692257189
Montserrat	61.644901758259316
North Korea	55.091436334162665
Laos	53.00590951961781
Cambodia	52.6960816578675

4.B. Conclusion

As we can see in the table above, the top 5 countries with the highest relative change percentage in CO2 emissions per capita are:

Curacao

Montserrat

North Korea

Laos

Cambodia

On the other hand, when considering the absolute change (the actual magnitude of change), following countries are in lead for actual reductions or increases in CO2 emissions over the same time span:

Curacao

Trinidad and Tobago

Brunei

Estonia

Mongolia

These findings illustrates that these countries had the most changes in their CO2 emissions relative to their population size over the given period (2015-2021). Both absolute and relative changes are useful in understanding the overall trends in CO2 emissions. Overall, **Curacao** stands out with the most significant reduction, showing a 78% decrease in CO2 emissions over the given period. The other countries also demonstrate reductions, showcasing the efforts being made globally for climate change.

Which countries are making the biggest strides in decreasing CO2 output?
Curacao
Montserrat

North Korea

Laos

Cambodia

5. Best price non-fossil fuel energy in the future

3- Which non-fossil fuel energy technology will have the best price in the future?

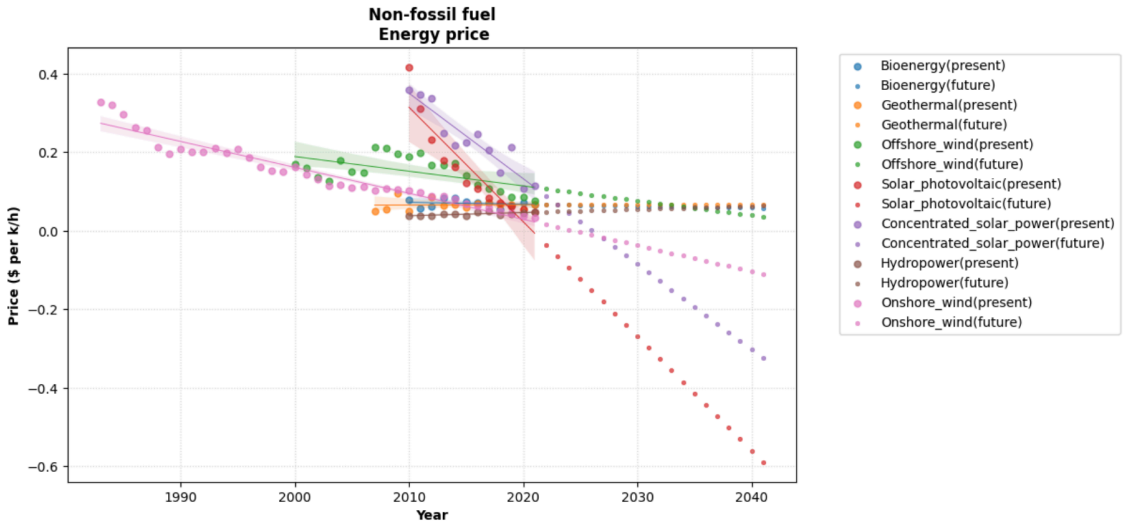
To determine which non-fossil fuel energy technology will have the best price in the future, data from https://ourworldindata.org/ has been used and a linear regression analysis on different non-fossil fuel energy technologies has been performed. The dataset provides information on the average cost per unit of energy generated by new power plants over their lifetime. The cost is measured in US dollars per kilowatt-hour and is adjusted for inflation.

5. A. Results

As you can see in the plot, the prices of **'Solar Photovoltaic'** and **'Concentrated Solar Power'** have dropped at a higher pace in comparison to other sources. Based on this data, it is likely that

Figure 03. Scatter plot of the correlations between non fossil energy prices in period of time (1980-2040)

these two technologies will have the best prices in the future. However, it's important to note that future developments and other external factors could also impact energy prices, so the prediction is not guaranteed. Nonetheless, this analysis provides valuable insights into the potential price trends for these renewable energy sources, suggesting that they could offer more competitive prices in the future if the current pace of decline continues.



5. B . Conclusion

In conclusion, the analysis of the levelized cost of energy for various non-fossil fuel technologies has provided insights into the potential price trends in the future.

The data indicates that 'Solar Photovoltaic' and 'Concentrated Solar Power' technologies have shown significant price drops over time, suggesting their potential for competitive pricing compared to other renewable energy sources.

While this analysis provides valuable predictions based on the current situations in world, It is essential to consider the influence of various factors and uncertainties that may affect energy prices in the future. Therefore, ongoing monitoring and assessment of energy markets will be crucial for making informed decisions regarding the adoption of sustainable and cost-effective energy sources in the future.

Which non-fossil fuel energy technology will have the best price in the future? **Solar Photovoltaic' and 'Concentrated Solar Power'**

6. Appendices

I- For a comprehensive presentation of the complete results, computer outputs, and additional charts related to the study on the biggest predictors of CO2 emissions, please refer to:

https://github.com/farimaahchz/07-/blob/main/07_CO2_01_predictors.ipynb

II- For datasets which has been used on biggest predictors of CO2 emissions, please refer to :

https://github.com/farimaahchz/07-/tree/main/DATA-%20CO2-FACTORS

III- For a comprehensive presentation of the complete results, computer outputs, and additional charts related to the study on the biggest striders in decreasing CO2 emissions, please refer to:

https://github.com/farimaahchz/07-/blob/main/07_CO2_02_biggest_strides_in_decreasing_CO2.ipynb

IV- For datasets which has been used on biggest striders in decreasing CO2 emissions, please refer to :

https://github.com/farimaahchz/07-/tree/main/DATA_CO2%20striders

V- For a comprehensive presentation of the complete results, computer outputs, and additional charts related to the study on the best price non-fossil fuel energy, please refer to:

https://github.com/farimaahchz/07-/blob/main/07_CO2_03_best_price_non__fossil_CO2.ipynb

VI- For datasets which has been used on the best price non-fossil fuel energy, please refer to :
https://github.com/farimaahchz/07-/tree/main/DATA_CO2_best_price_fuel