Final assignment - CO2 emissions

Winc academy course "Data analytics met Python" 2023 - 2024

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Overview

About CO2 emissions there is a lot to discuss, but on one thing a lot of people agree, the earth needs less of it. To limit CO2 emission, we first look at what the biggest predictor of a large CO2 output per capita of a country is and which countries are making the biggest strides in decreasing this CO2 output. Numbers not only show correlation between fossil energy and CO2 emissions, but also between the use of energy per capita worldwide and growing use of non-fossil energy resources. For that reason it is important to know which non-fossil fuel energy technology will have the best price in the future to meet both the energy demand as the need for less CO2 emissions.

Link to Github with codes and datasets used:
https://github.com/pepijnvanschijndel/Winc-Final-Assesment-Pepijn-van-Schijndel

Data and model

Predicting CO2 output per capita

The biggest predictor of a large CO2 output per capita of a country can vary depending on numerous factors such as economic structure, industrialization level, energy sources, government policies, and cultural practices.

In this research I will compare CO2 ouput per capita to the following assets

1. **Economic Development**: In what way the GDP correlates to CO2 emissions per capita?

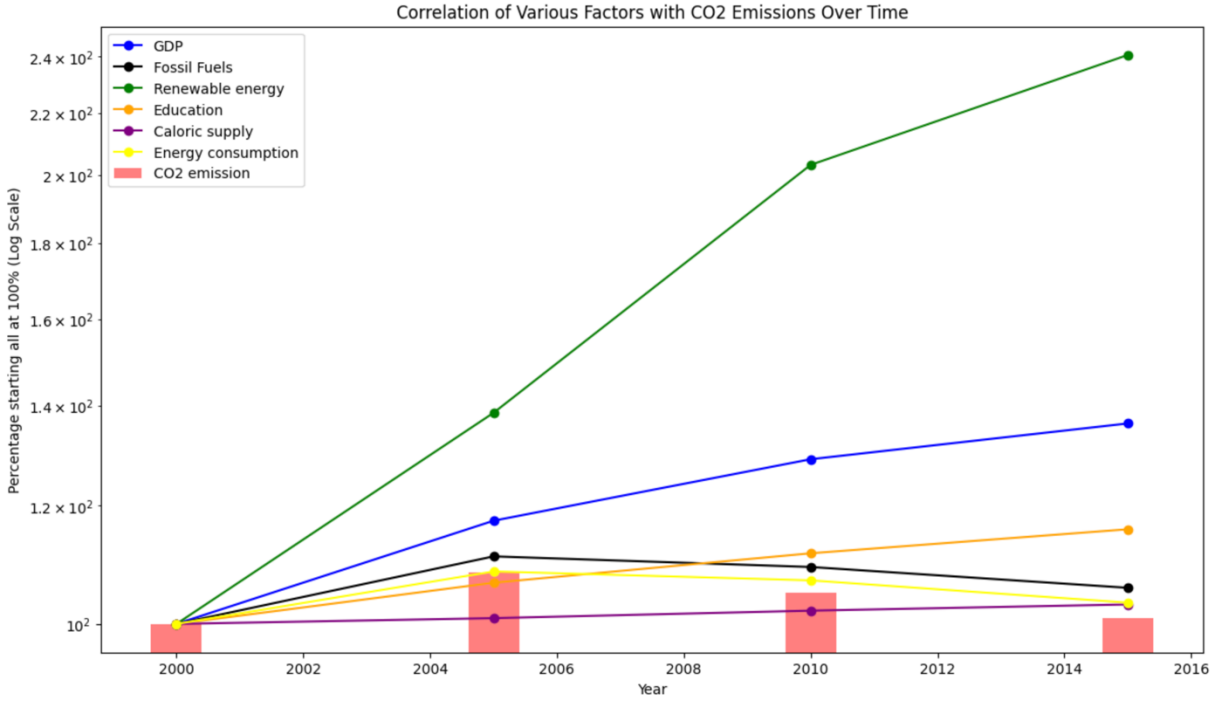
2. **Energy Consumption and Sources**: Does decreasing the use of fossil fuels such as coal, oil, and natural gas and increasing renewable energy sources like wind, solar, and hydroelectric power for energy production per capita decrease CO2 emissions?

3. **Education**: What influence has educating people on CO2 emissions per capita?

4. **Diet**: Is there a connection between calories per day and the CO2 emissions per capita? especially standards are to low or to high?

It's important to note that these factors often interact with each other, and the relative importance of each factor can vary depending on the specific context of a country. Additionally, other social, political, and geographical factors may also play a role in CO2 emissions per capita.

The first graph I made (shown here) I found out that the line following the CO2 emission most similar, should be the most predictive and therefore has the most impact. Then I decided to make a new graph where I divided each variable by the 'CO2 emission' for each year to show the relative impact, this is used in the results.



Researched countries and period of time

For the research "Predicting CO2 output per capita" and "Biggest strides in decreasing CO2 output", the analysis contains a list of countries from the year 2000 - 2016 as more data was available then before 2000. 2016 was the newest year in this dataset. The countries researched are Algeria, Argentina, Australia, Austria, Bangladesh, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Czechia, Denmark, Ecuador, Egypt, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Kazakhstan, Kuwait, Latvia, Lithuania, Luxembourg, Malaysia, Mexico, Morocco, Netherlands, New Zealand, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Trinidad and Tobago, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States, Venezuela and Vietnam.

Biggest strides in decreasing CO2 output

To define which country makes the biggest strides in decreasing CO2 output, I have to calculate the relative decrease in CO2 emissions over time for each country and identify the country with the highest percentage decrease. For the research "Predicting CO2 output per capita", I already included the CO2 emission per capita data, which is relative to the population as well and therefore this same data is used for researching "Biggest strides in decreasing CO2 output"

Predicting future prices of non-fossil fuel energy

Predicting future prices of non-fossil fuel energy accurately requires consideration of various factors such as technological advancements, market demand, policy changes, and economic conditions. For this study it is based on historical data and current situations in the countries.

For analyzing historical price trends and making rough predictions about future prices based on those trends I used linear regression, a statistical model which estimates the linear relationship between a scalar response and explanatory variable(s). In this case it is used to predict future price based on historical price data for various energy technologies which shows the average cost per unit of energy generated across the lifetime of a new power plant. This data is expressed in US dollars per kilowatt-hour. It is adjusted for inflation but does not account for differences in the cost of living between countries.

This graph includes prices of:

1. **Solar panels**
Solar panels, named photovoltaics in my research, use the power of the sun.

2. **Wind turbines**
Wind turbines use the power of wind. This dataset only contains data of windturbine costs for Denmark.

3. **Geothermal electricity**
Geothermal electricity is generated from geothermal energy.

4. **Concentrating solar**
By using mirrors to concentrate sunlight into one spot, generating heat to be used as energy to feed heat engines or thermal reactions generating electricity.

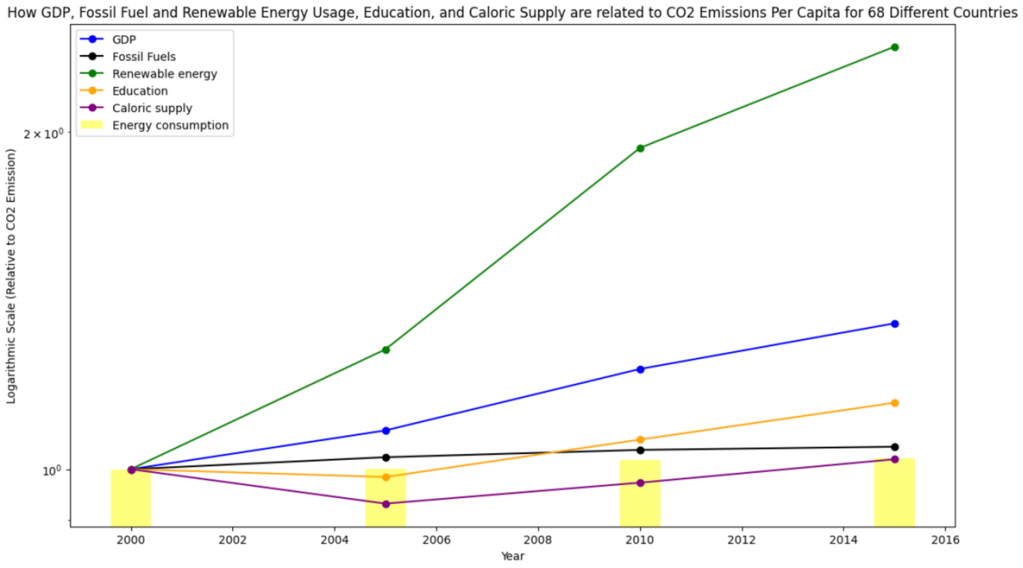
Researched countries and period of time

For the research "Predicting future prices of non-fossil fuel energy", the analysis is not country specific and based on worldide figures, except the research on windturbine the dataset only contained data of windturbine costs for Denmark.
Concentrating solar is measured from 1981 - 2005, Geothermal electricity is measured from 1981 - 2005, Photovoltaics is measured from 1981 -2013 and Wind turbine (Denmark) is measured from 1981 - 2000.

Results

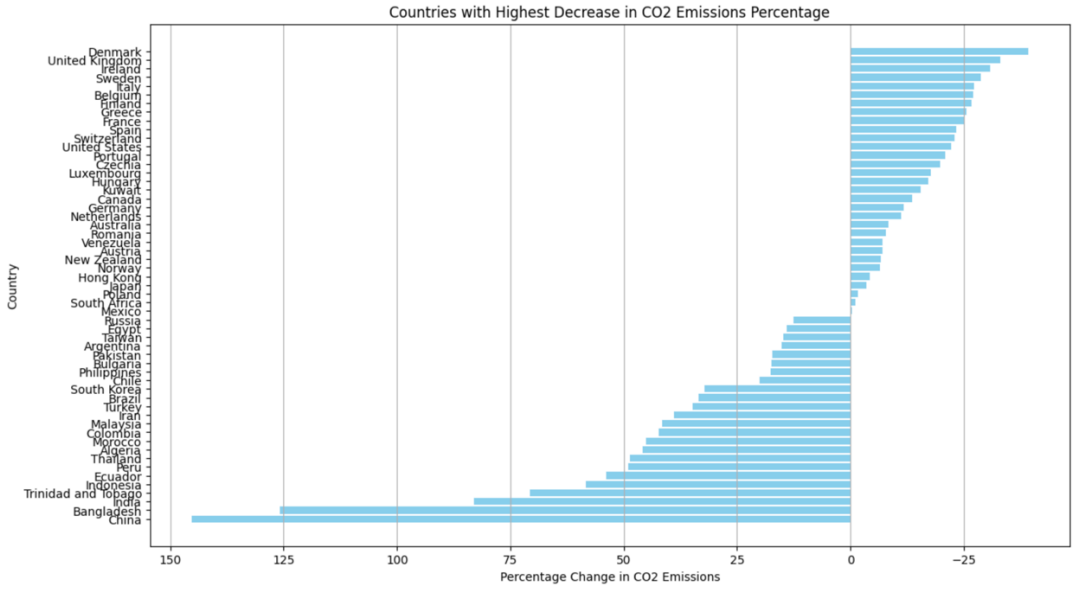
Predicting CO2 output per capita results

This graph shows the relative impact on CO2 emission each year for every asset in percentage.



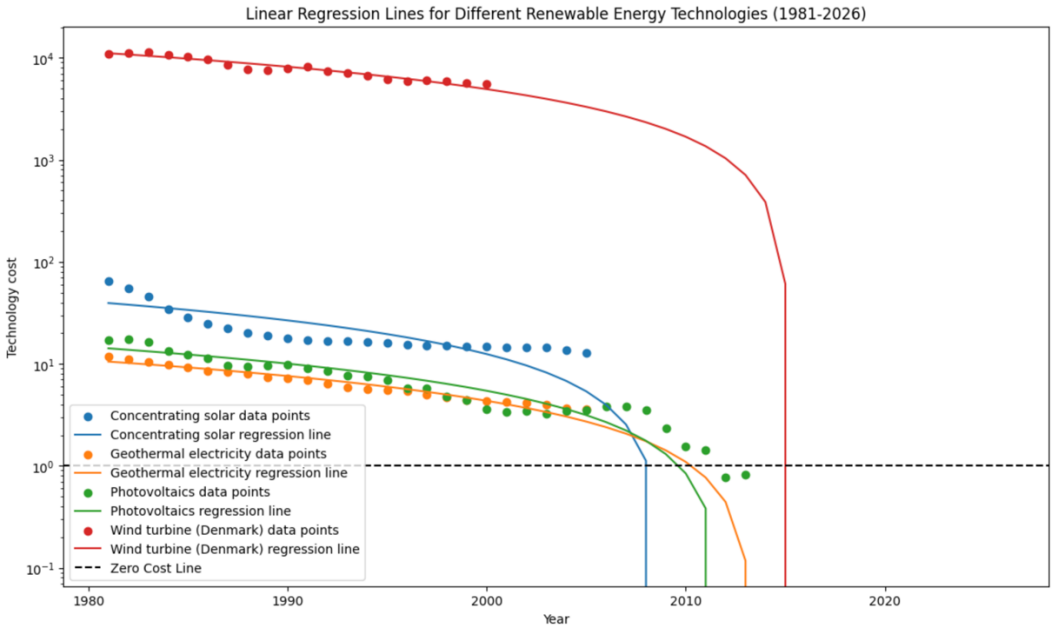
Biggest strides in decreasing CO2 output results

This graph shows the relative decrease in CO2 emissions over time for each country in percentage.



Predicting future prices of non-fossil fuel energy results

This graph shows the linear regression of future technology prices based on historical price data for various energy technologies. For every technology it states the average cost per unit of energy generated across the lifetime of a new power plant and is expressed in US dollars per kilowatt-hour.



Conclusion

In the research the use of fossil energy was one-on-one following the CO2 emission per capita, indicating that the transition from fossil fuels to renewable energy sources is crucial for reducing CO2 emissions and combating climate change.

Propabely due to increased industrial activities, energy consumption, and higher standards of living every capita demanded more energy and the use of energy per capita increased first until 2005, but decreased after 2005. It is likely that improved energy efficiency and technologies caused that. Overall the increase of used renewable energy sources per capita shows that it meets the demands of increased energy consumption while depending less on the use of fossil energies.

Countries in Europe showed biggest steps in decreasing CO2 output per capita, Denmark leading with a decrease of -39.19% in a period of 15 years.

The historical price trends of non-fossil fuel energy technologies—solar panels, wind turbines, geothermal electricity, and concentrating solar power—indicate a downward trajectory in costs, mainly due to technological advancements and economies of scale. Solar panels in particular, have seen substantial price reductions, making them increasingly competitive with fossil fuels.

Despite these decreasing costs, several factors prevent renewable energy prices from dropping below zero. These include production and installation Costs, resource availability, infrastructure and storage and of course the policy and regulatory frameworks.

The future of energy lies in the continued reduction of renewable energy costs, though prices will never fall below zero due to the inherent costs of production, infrastructure, and resource management.

Overall, a concerted global effort to reduce the use of fossil energies, making technological advancements and sustainable practices on renwable energy is essential to meet energy demands while significantly reducing CO2 emissions and addressing climate change.

Appendix

All data used is from the https://ourworldindata.org/ website, their mission is making the best research and data accessible and understandable, to empower those working to build a better world. Their work is free to use and open source.

Population

What is the density of the population in surface per capita of a country?

File: population-and-demography.csv

Source population
United Nations, World Population Prospects (2022) – processed by Our World in Data. “Population” [dataset]. United Nations, World Population Prospects (2022) [original data].

CO2 Emission

What is the CO2 emission per capita of a country?

File**:** co-emissions-per-capita.csv

Source CO2 emissions per capita
Global Carbon Budget (2023); Population based on various sources (2023) – with major processing by Our World in Data. “Annual CO_2 emissions (per capita) – GCB” [dataset]. Global Carbon Project, “Global Carbon Budget”; Various sources, “Population” [original data].

Economic development

What is the GDP per capita of a country?

File: gdp-per-capita-maddison.csv

Source GDP per capita
Bolt and van Zanden - Maddison Project Database 2023 – with minor processing by Our World in Data. “GDP per capita – Maddison Project Database – Historical data” [dataset]. Bolt and van Zanden, “Maddison Project Database 2023” [original data]. Retrieved June 9, 2024 from https://ourworldindata.org/grapher/gdp-per-capita-maddison

Energy Consumption and Sources

What is the fossil fuel consumption per capita of a country? What is the consumption of renewable energy sources like wind, solar, and hydroelectric power for energy production per capita of a country?

Files: per-capita-energy-use.csv, fossil-fuels-per-capita.csv, modern-renewable-energy-consumption.csv

Source energy consumption per capita
U.S. Energy Information Administration (2023); Energy Institute - Statistical Review of World Energy (2023); Population based on various sources (2023) – with major processing by Our World in Data. “Primary energy consumption per capita” [dataset]. U.S. Energy Information Administration, “International Energy Data”; Energy Institute, “Statistical Review of World Energy”; Various sources, “Population” [original data].

Source fossil fuel per capita
Energy Institute - Statistical Review of World Energy (2023); Population based on various sources (2023) – with major processing by Our World in Data. “Fossil fuel consumption per capita” [dataset]. Energy Institute, “Statistical Review of World Energy”; Various sources, “Population” [original data].

Source renewable energy per capita
Energy Institute - Statistical Review of World Energy (2023) – with major processing by Our World in Data. “Electricity generation from hydropower” [dataset]. Energy Institute, “Statistical Review of World Energy” [original data].

Education

What is the time spent in school for a capita of a country?

File: mean-years-of-schooling-long-run.csv

Source schooling per capita
Barro and Lee (2015); Lee and Lee (2016) – with major processing by Our World in Data. “Average years of schooling” [dataset]. Barro and Lee, “Projections of Educational Attainment”; Lee and Lee, “Human Capital in the Long Run” [original data].

Diet

How much caloric supply does every capita per country have?

File: daily-per-capita-caloric-supply.csv

Source daily caloric supply per capita
Food and Agriculture Organization of the United Nations (2023); Harris et al. (2015); Floud et al. (2011); Jonsson (1998); Grigg (1995); Fogel (2004); Food and Agriculture Organization of the United Nations (2000); Food and Agriculture Organization of the United Nations (1949); USDA Economic Research Service (ERS) (2015) – with major processing by Our World in Data. “Daily calorie supply per person” [dataset]. Food and Agriculture Organization of the United Nations, “Food Balances: Food Balances (-2013, old methodology and population)”; Food and Agriculture Organization of the United Nations, “Food Balances: Food Balances (2010-)”; Harris et al., “How Many Calories? Food Availability in England and Wales in the Eighteenth and Nineteenth Centuries”; Floud et al., “The Changing Body”; Jonsson, “Changes in food consumption in Iceland, 1770-1940”; Grigg, “The nutritional transition in Western Europe”; Fogel, “The Escape from Hunger and Premature Death”; Food and Agriculture Organization of the United Nations, “The State of Food and Agriculture 2000”; Food and Agriculture Organization of the United Nations, “The State of Food and Agriculture 1949”; USDA Economic Research Service (ERS), “U.S. food supply: Nutrients and other food components, per capita per day” [original data].

Costs of different technologies

For answering Best future price for non-fossil fuel energy, What is the cost of different technologies over time?

File: costs-of-66-different-technologies-over-time.csv

Source population
Farmer and Lafond (2016) – with minor processing by Our World in Data. “The cost of 66 different technologies over time” [dataset]. Farmer and Lafond, “How predictable is technological progress?” [original data]. Retrieved June 18, 2024 from https://ourworldindata.org/grapher/costs-of-66-different-technologies-over-time