

# Energy emission and power report

## 1) Energy emission and power analysis:

- A deep study of various energy consumption and production over the years by various countries of 7 continents.

## 2) Introduction:

- This report presents an exploratory data analysis (EDA) project on energy emissions and power, using a dataset obtained from a reliable source. The dataset includes various energy-related indicators, such as CO2 emissions, energy consumption, primary production, and electricity production, among others. The objective of the analysis is to gain insights into the global energy landscape, understand the trends and patterns in energy production and consumption, and explore the relationship between energy use and environmental impact. Through this analysis, we aim to identify potential areas for energy policy interventions and suggest ways to improve the sustainability of energy systems. This report is an EDA project on energy emissions and power using a reliable dataset. Our objective is to gain insights into global energy trends, patterns, and their environmental impact. We aim to identify areas for energy policy interventions and suggest ways to improve energy sustainability.

## 3) Data Description:

- The dataset used in this EDA project on energy emissions and power comprises various energy-related indicators, covering a range of countries and regions. The following is a description of each column in the dataset.
- CO2 emissions from fuel combustion: This column indicates the amount of carbon dioxide emissions resulting from the combustion of fossil fuels (coal, oil, and gas) in a country. The unit of measurement is metric tons (tCO2).
- CO2 intensity: This column measures the ratio of CO2 emissions from fuel combustion to gross domestic product (GDP), expressed in constant US dollars at purchasing power parities. It indicates the amount of CO2 emitted to generate one unit of GDP.
- Crude oil, coal, and lignite production: This column represents the gross production of crude oil, coal, and lignite in a country. The unit of measurement is million tons (Mt).
- Electricity production: This column indicates the gross production of electricity in a country, including public production by private and public electricity utilities and industrial producers for their own use. The unit of measurement is terawatt hours (TWh).
- Energy intensity of GDP at constant purchasing power parities: This column measures the ratio of primary energy consumption to GDP, expressed in constant US dollars at purchasing power parities. It indicates the total amount of energy required to generate one unit of GDP.

- Natural gas production: This column represents the marketed production of natural gas in a country, excluding quantities flared or re injected. The unit of measurement is billion cubic meters (bcm).
- NGL: This column represents the production of natural gas liquids in a country. The unit of measurement is million tons of oil equivalent (Mtoe).
- Oil products: This column represents all liquid hydrocarbons obtained by refining crude oil and NGL, as well as those obtained by treatment of natural gas. The unit of measurement is million tons (Mt).
- Share of renewables in electricity production: This column indicates the ratio of electricity produced from renewable sources (hydro, wind, geothermal, and solar) to the total electricity production.
- Share of wind and solar in electricity production: This column indicates the ratio of electricity produced from wind and solar sources to the total electricity production.
- Share of electricity in total final energy consumption: This column indicates the ratio of final electricity demand to the total final energy consumption.
- Total primary production: This column represents the quantity of natural energy resources extracted or produced, excluding quantities flared or re injected for natural gas. The unit of measurement is million tons of oil equivalent (Mtoe).
- Total energy consumption: This column indicates the total energy consumption, including primary production, external trade, marine bunkers, and stock changes. The unit of measurement is million tons of oil equivalent (Mtoe).
- Average CO<sub>2</sub> emission factor: This column indicates the average CO<sub>2</sub> emission factor or carbon factor, calculated as the ratio of emissions over primary energy consumption. The unit of measurement is kilogram of carbon dioxide (kCO<sub>2</sub>)/toe.
- Note: toe stands for tons of oil equivalent, koe for kilo of oil equivalent, and bcm for billion cubic meters.

#### **4) Data cleaning and preprocessing:**

- Data cleaning and preprocessing is a crucial step in any data analysis project. In this project, several steps were taken to clean and preprocess the data before performing exploratory data analysis. Our first step was to identify if there are any anomalies or null values in the dataset. We found some null values with some string values named n.a , we replaced these values with 0 to make them numerical.
- During our second step we found out which columns are having these values. There were seven columns which could make data understanding difficult, so we replace these anomalies with their mean or median .Overall; these steps ensured that the data was clean, consistent, and ready for exploratory data analysis.

## 5) Exploratory Data Analysis:

- Exploratory data analysis is an important step in any data analysis project. In this section, I have summarized the main findings and insights from the analysis of the energy dataset.
- For various nations, fuel combustion-related CO<sub>2</sub> emissions (MtCO<sub>2</sub>) China and the United States emit the most carbon dioxide (CO<sub>2</sub>) from fuel combustion with 5724 and 5296 MtCO<sub>2</sub>, respectively, while New Zealand emits the least with 29 MtCO<sub>2</sub>. Russia, India, and Japan also emit a lot of CO<sub>2</sub> from fuel combustion, while Norway, Sweden, Portugal, and Nigeria emit little CO<sub>2</sub>. The typical CO<sub>2</sub> emission factor for various nations, expressed as tCO<sub>2</sub>/toe. With 3.24 tCO<sub>2</sub>/toe, Poland has the highest CO<sub>2</sub> emission factor, while Nigeria has the lowest with 0.52 tCO<sub>2</sub>/toe. While Sweden, Canada, Norway, France, and Brazil have lower emission factors, Kazakhstan, Australia, South Africa, and China also have high emission factors. CO<sub>2</sub> intensity at various nations' constant purchasing power parities (kCO<sub>2</sub>/15p). Sweden, Columbia and Norway have the most reduced (kCO<sub>2</sub>/15p). The top 40 energy-producing nations' total energy production in Mtoe (million tons of oil equivalents) as of 2021. China and the United States of America produce the most energy, followed by Saudi Arabia, India, and Russia. The information shows a grouping of energy creation in a couple of nations, with the main five nations representing over half of the all-out creation. Because of the significant contributions they make from natural gas and coal, Australia and Canada are on top of the list. The disparity in energy production between developed and developing nations is emphasized on the list. As a result of their dependence on imports to meet their energy needs, many European countries rank lower on the list. Total energy consumed by various nations, expressed as Mtoe (million tons of oil equivalents). With 2167.446827 Mtoe, the United States of America leads the list, followed by China with 1923.259065 Mtoe and Russia with 691.661445 Mtoe. With 579.979809 Mtoe and 476.681403 Mtoe, respectively, India and Japan complete the top five. Generally, the information shows that the top energy-consuming nations are likewise among the top energy-creating nations. However, the ranking on the two lists differs slightly, indicating that some nations export a significant amount of their energy production. Share of renewable energy in electricity production for various nations with 98.74 percent, Norway leads, followed by Brazil with 86.86 percent and Colombia with 75.21 percent. New Zealand, Venezuela, Canada, and Sweden are among the other nations with high shares. Saudi Arabia, Kuwait, and the United Arab Emirates, on the other hand, have the lowest shares, all of which are below one percent. China has 19.49%, while the United States has a relatively small share of 11.79 percent. Proportion of electricity to total final energy consumption in different nations. Norway has the most elevated share at 46.8%, trailed by Sweden and Taiwan. With just 1.4%, Nigeria has the lowest percentage. Indonesia, Iran, Uzbekistan, Algeria, and India are other nations with low shares. The US has a portion of 20.4%, and other significant nations like China, Japan, Germany, and the Unified Realm have divides among 13% and 25%. Various nations' domestic consumption of oil products in millions of metric tons (Mt). The US has the most noteworthy utilization at 786.732 Mt, trailed by China at 341.863 Mt and Japan at 204.883 Mt. The main 10 likewise incorporates Russia, India, Germany, Canada, Brazil, South Korea, and Mexico. The refined oil products production in million tons (Mt) by country suggests that, despite efforts to switch to cleaner energy sources, oil remains a significant source of energy for many nations. With 828.21 Mt, the United States is the largest producer. China is next with 338.95 Mt, followed by Russia with 226.89 Mt. Other major producers include Germany, Japan, India, South Korea, Saudi Arabia, Canada, Brazil, Italy, and the United Kingdom. Czech, Nigeria, Uzbekistan, and New Zealand

are the countries with the lowest output on the list. Country-by-country production of natural gas (in billion cubic meters). With 631.07 bcm and 616.44 bcm, respectively, Russia and the United States are the world's leading natural gas producers. Norway, Iran, and Canada also produce a lot of natural gas. The Netherlands, China, Indonesia, the United Kingdom, and Saudi Arabia are other notable producers. Then again, a few nations on the rundown have extremely low petroleum gas creation, like Portugal, Sweden, and Belgium. Natural gas creation and utilization by country in billion cubic meters (bcm). With 672.28 bcm, the United States consumes the most natural gas domestically, followed by Russia with 438.23 bcm. Russia produces 631.07 bcm of natural gas annually, followed by the United States (616.44 bcm), Canada (165.97 bcm), Iran (110.09 bcm), and Norway (79.80 bcm). At constant purchasing power parities, the energy intensity of GDP is the amount of energy required to produce one unit of economic output. It is expressed as kilograms of oil equivalent per dollar. With 0.49 koe per 15, *usbekistan has the highest GDP energy intensity, while Colombia has the lowest with 0.07 koe\per 15*. Among the main 10 nations with the most elevated energy force of Gross domestic product, six are from the previous Soviet Association, in particular Uzbekistan, Ukraine, Russia, Kazakhstan, Belarus, and Azerbaijan. China, the world's largest energy consumer, is ranked third with an energy intensity of GDP of 0.26 koe/15. *electricity production in terawatt per hour (TWh) for various countries. The United States of America is ranked 14th with an energy intensity of GDP of 0.15 koe/15*. With 4025.54 TWh, the United States leads the world in electricity production; followed by China with 3230.40 TWh. India, Russia, and Japan come in second place among producers. Canada, Germany, France, Brazil, and South Korea balance the main ten. With 23.11 TWh, Nigeria is the lowest producer on the list. Various nations' domestic electricity consumption in TWh. With 3587.24 TWh, the United States consumes the most electricity domestically, followed by China with 2785.25 TWh and Japan with 953.27 TWh. Russia and India balance the main five with homegrown power utilization of 801.99 TWh and 609.71 TWh, individually. Nigeria has the lowest domestic electricity consumption of any country in the dataset, at 16.62 TWh. Domestic consumption of coal and lignite in million tons (Mt) for various countries China consumes the most coal and lignite domestically with 2427.75 Mt, followed by the United States with 858.99 Mt and India with 557.08 Mt. Germany, Russia, South Africa, and Japan also consume a lot of coal and lignite domestically. In some nations, such as Saudi Arabia, Kuwait, Nigeria, Venezuela, and the United Arab Emirates, coal and lignite use is relatively low. Different nations use wind and solar energy to produce electricity. With 12.81% of electricity production coming from wind and solar power, New Zealand leads the world. Spain and Portugal come in second and third with 10.51% and 10.06%, respectively. Germany, Italy, and the Assembled Realm likewise have somewhat high portions of wind and sun based energy in their power creation. Crude oil production data (in million tons) for various nations. On the other hand, countries like Uzbekistan, Saudi Arabia, Venezuela, and Nigeria use very little, if any, wind and solar energy to generate electricity. With 478.65 million tons, Saudi Arabia leads the list, followed by Russia with 443.44 million tons and the United States with 420.06 million tons, respectively. Iran, China, Canada, and Mexico are all significant oil producers. The information additionally shows that numerous nations produce moderately limited quantities of unrefined petroleum. Coal and lignite creation (in million tons) of various nations all over the planet. China produces the most with 2354.266 million tons, followed by India with 470.919 million tons and the United States with 915.704 million tons. Other prominent makers incorporate Australia, Russia, Indonesia, and South Africa, all with creation levels north of 200 million tons.

There has been increase and decrease in various energy , power and fuel over the years (1990-2020) here is a quick overview-

CO2 emissions from fuel combustion (MtCO <sub>2</sub> )	- 428 - 665 (Mtco <sub>2</sub> )
Average CO2 emission factor (tCO <sub>2</sub> /toe)	- 2.17 - 2.26 (Tco <sub>2</sub> /toe)
CO2 intensity at constant purchasing power parities (kCO <sub>2</sub> /\$15p)	- 0.2 -0.4 (kco <sub>2</sub> /\$15 p)
Total energy production (Mtoe)	- 182.9 - 281.1 (Mtoe)
Total energy consumption (Mtoe)	- 177.3 - 275.6 (Mtoe)
Share of renewables in electricity production	- 22.2 - 27.7 (%)
Share of electricity in total final energy consumption	- 15 - 20.2 (%)
Oil products domestic consumption (Mt)	- 65 - 86.7 (Mt)
Refined oil products production (Mt)	- 59.6 - 75.8 (Mt)
Natural gas production (bcm)	- 44.7 - 75.2 (bcm)
Natural gas domestic consumption (bcm)	- 44.5 - 77.8 (bcm)
Energy intensity of GDP at constant purchasing power parities (koe/\$15p)	- 0.117 - 0.177 (koe)
Electricity production (TWh)	- 259.4 - 543.3 (TWh)
Electricity domestic consumption (TWh)	- 222.8 - 471.4 (TWh)
Coal and lignite domestic consumption (Mt)	- 96 - 170.1 (Mt)
Share of wind and solar in electricity production (%)	- 0.4 - 7.4 (%)
Crude oil production (Mt)	- 64.9 - 84.1 (Mt)
Coal and lignite production (Mt)	- 96 - 172.4 (Mt).

## 6) Conclusion:

- Globally, there were significant shifts in energy consumption and emission patterns from 1990 to 2020. Countries are putting more emphasis on lowering emissions and promoting sustainability as they become more aware of the negative effects that energy production and consumption have on the environment.
- Countries made significant investments in solar, wind, and hydropower technologies during this time, resulting in a remarkable rise in the use of renewable energy sources. The potential for long-term sustainability and lower carbon emissions of renewable energy sources prompted this shift. As a result, renewable energy capacity increased and its share of the overall energy mix steadily increased.
- Also notable were efforts to cut power use and increase energy efficiency. Energy-efficient appliances, smart grids, and sustainable building codes are examples of policies and regulations that were enacted by governments and organizations to promote energy-saving practices and technologies. In many developed nations, as a result, per capita power consumption generally decreased.
- However, energy consumption and emission patterns differed significantly from country to country. Energy demand increased dramatically in developing nations as a result of their rapid industrialization and economic expansion, leading to an increase in emissions and power consumption. They still face difficulties achieving a balance between sustainable economic growth and environmental conservation.
- Energy emissions were difficult to reduce in nations heavily dependent on fossil fuels. Significant investments in infrastructure, technology, and policy frameworks are required for the switch to renewable energy. Worldwide participation and coordinated effort are vital to address worldwide energy and environment objectives really.
- Countries can work toward a future that is less polluting and more sustainable by embracing these challenges and opportunities. While ensuring that everyone has equal access to clean energy, innovative solutions must be given top priority. We can lessen the negative effects of climate change, cut energy emissions, and make the world greener and more prosperous through global cooperation.