**BU EDGE CSE**

**"Global Sustainable Energy; The Future in our Hand "**



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**Abstract:**

This study analyzes global data on sustainable energy from 2000 to 2020, offering a comprehensive assessment of key energy indicators including electricity access, renewable energy capacity, carbon emissions, energy intensity, financial flows, and economic growth across countries. The analysis tracks global progress toward Sustainable Development Goal 7 (SDG 7) – ensuring universal access to affordable, reliable, sustainable, and modern energy for all. By comparing trends between developed and developing nations, the research highlights disparities in electricity access, renewable energy adoption, and carbon emissions reduction. It examines how financial flows to developing countries have supported clean energy transitions, with a focus on renewable energy share, energy efficiency, and decarbonization efforts. The findings provide valuable insights into the relationship between energy consumption, economic growth, and sustainability, emphasizing challenges such as high initial costs, technological limitations, and regulatory barriers. Ultimately, this study underscores the importance of global collaboration in accelerating the energy transition and achieving a low-carbon, inclusive, and sustainable energy future.

**Keywords:** Sustainable energy, renewable energy, electricity access, carbon emissions, energy intensity, financial flows, economic growth, SDG 7, energy transition, global energy consumption, developing countries, energy efficiency, decarbonization.

**Introduction:**

Global data on sustainable energy, spanning from 2000 to 2020, offers a rich tapestry of insights into the world’s progress toward a more sustainable and equitable energy future. This data reveals key sustainable energy indicators, such as electricity access, renewable energy capacity, carbon emissions, energy intensity, and financial flows, which are critical for assessing both current energy systems and future energy transitions. Access to electricity and clean cooking fuels are fundamental indicators of energy poverty and development, highlighting disparities between nations and regions. The growing share of renewable energy in the global energy mix, alongside the transition from fossil fuels to cleaner sources, is a key factor in combating climate change and achieving low-carbon economies. Carbon emissions data allows for the evaluation of environmental impact, helping track progress in mitigating climate change and meeting international climate commitments. Energy intensity—measuring energy consumption relative to economic output—provides insights into energy efficiency and the sustainability of economic growth. Financial flows to developing countries, aimed at supporting clean energy investments, play a crucial role in fostering the transition to renewables and ensuring that all nations can contribute to the global sustainability effort. The relationship between energy consumption and economic growth is explored through metrics such as GDP growth and energy consumption per capita, helping to understand how energy access supports broader socio-economic development. These indicators also track progress towards Sustainable Development Goal 7, which aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. By comparing nations and examining trends over two decades, this data offers profound insights into global energy consumption patterns, highlighting successes, challenges, and opportunities for accelerating the shift toward sustainable, inclusive, and low-carbon energy systems.

**Defining Sustainable Energy**

Sustainable energy refers to energy sources that can be replenished naturally and can be used without depleting the Earth's natural resources or causing harm to the environment. Sustainable energy sources include renewable energy sources like solar, wind, hydro, geothermal, and biomass. Sustainable energy production and consumption also involve minimizing energy waste and maximizing energy efficiency.

The concept of sustainable energy is based on the principles of sustainability, which aim to meet the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable energy systems are designed to ensure that the energy used today does not compromise the availability of energy for future generations.

Sustainable energy is a critical component of a sustainable future, as it plays a key role in reducing greenhouse gas emissions, mitigating climate change, and protecting the environment. By transitioning to sustainable energy sources and practices, we can reduce our dependence on non-renewable energy sources, promote energy independence, and create a more sustainable and equitable world

**Data Set Analysis:**

* **Entity**: The name of the country or region for which the data is reported.
* **Year**: The year for which the data is reported, ranging from 2000 to 2020.
* **Access to electricity (% of population)**: The percentage of population with access to electricity.
* **Access to clean fuels for cooking (% of population)**: The percentage of the population with primary reliance on clean fuels.
* **Renewable-electricity-generating-capacity-per-capita**: Installed Renewable energy capacity per person
* **Financial flows to developing countries (US $)**: Aid and assistance from developed countries for clean energy projects.
* **Renewable energy share in total final energy consumption (%)**: Percentage of renewable energy in final energy consumption.
* **Electricity from fossil fuels (TWh)**: Electricity generated from fossil fuels (coal, oil, gas) in terawatt-hours.
* **Electricity from nuclear (TWh)**: Electricity generated from nuclear power in terawatt-hours.
* **Electricity from renewables (TWh)**: Electricity generated from renewable sources (hydro, solar, wind, etc.) in terawatt-hours.
* **Low-carbon electricity (% electricity)**: Percentage of electricity from low-carbon sources (nuclear and renewables).
* **Primary energy consumption per capita (kWh/person)**: Energy consumption per person in kilowatt-hours.
* **Energy intensity level of primary energy (MJ/$2011 PPP GDP)**: Energy use per unit of GDP at purchasing power parity.
* **Value\_co2\_emissions (metric tons per capita)**: Carbon dioxide emissions per person in metric tons.
* **Renewables (% equivalent primary energy)**: Equivalent primary energy that is derived from renewable sources.
* **GDP growth (annual %)**: Annual GDP growth rate based on constant local currency.
* **GDP per capita**: Gross domestic product per person.
* **Density (P/Km2)**: Population density in persons per square kilometer.
* **Land Area (Km2)**: Total land area in square kilometers.
* **Latitude**: Latitude of the country's centroid in decimal degrees.
* **Longitude**: Longitude of the country's centroid in decimal degrees.

**Methodology**

The analysis was conducted using Microsoft Excel, with pivot tables as the primary tool for summarizing and extracting insights from the data. Each key sustainable energy indicator was analyzed by creating pivot tables to examine relationships between different variables. Below is an outline of the approach used for each analysis:

**1. Electricity Access by Country and Region:** A pivot table was created to calculate the percentage of the population with access to electricity in each country and region from 2000 to 2020.This helped identify regions with the lowest electricity access and track improvements over time.

**2. Renewable Energy Share in Total Energy Consumption:** A pivot table was used to analyze the percentage of renewable energy in total energy consumption across countries. This provided insights into which countries are leading the transition to clean energy and which are lagging.

**3. Carbon Emissions Trends by Country and Sector:** A pivot table summarized carbon emissions by country and economic sector (e.g., industry, transportation, residential).This allowed for the identification of high-emission countries and major contributing sectors.

**4. Energy Intensity by Country (Energy Use per Unit of GDP):** A pivot table was created to compare energy intensity, measuring the amount of energy used per unit of GDP.This helped track improvements in energy efficiency and economic sustainability across nations.

**5. Financial Flows into Sustainable Energy Projects:** A pivot table was used to analyze investments in renewable energy and energy efficiency projects by country and region.This provided insights into global financial commitments and disparities in funding for sustainable energy.

**6. Economic Growth and Energy Consumption Trends:** The relationship between GDP growth and energy consumption was examined through pivot tables.This helped determine whether economic expansion is driven by fossil fuels or a shift toward sustainable energy sources.

**7. Progress Toward Sustainable Development Goal 7 (SDG 7):** A pivot table was used to track progress on SDG 7 indicators, such as universal energy access, increasing renewable energy adoption, and improving energy efficiency.This allowed for a comparative analysis of countries working toward achieving global sustainability goals.

**8. Developed vs. Developing Countries in Energy Transition:** Countries were categorized into developed and developing economies, and pivot tables were used to compare their progress in sustainable energy adoption.This analysis highlighted disparities in electricity access, renewable energy investments, and carbon reduction efforts.

**9. Off-Grid and Mini-Grid Renewable Solutions:**A pivot table was created to analyze off-grid renewable energy solutions (e.g., solar home systems, mini-grids) in rural areas.This helped assess the role of decentralized energy in improving energy access.

**10. Government Policies and Their Impact on Energy Transition:** A qualitative review was conducted to examine government policies supporting renewable energy and energy efficiency.The impact of subsidies, incentives, and regulations on energy transition was analyzed alongside quantitative data.

This methodology provided comprehensive insights into global sustainable energy trends, allowing for comparisons between countries, tracking progress, and identifying key challenges in achieving a clean and sustainable energy future.

**Results and Discussion**

**1. Electricity Access Trends**

Electricity access has significantly improved worldwide, with many developing countries experiencing rapid electrification. In 2000, sub-Saharan Africa had the lowest electricity access rates, with some countries below 20%. By 2020, global electricity access reached approximately 90%, with South Asia and sub-Saharan Africa making substantial progress due to rural electrification programs and off-grid solutions. Despite these advancements, disparities remain, particularly in rural and remote areas.

**2. Renewable Energy Share in Total Energy Consumption**

The share of renewable energy in total energy consumption has steadily increased, driven by government policies, technological advancements, and financial investments. Countries like Germany, Sweden, and Brazil have led the transition, with renewables accounting for over 40% of their final energy consumption. In contrast, fossil fuel-dependent nations, such as those in the Middle East, have slower transitions. Hydropower remains dominant, while solar and wind energy have shown exponential growth.

**3. Carbon Emissions Trends**

Global carbon emissions have fluctuated due to economic growth, energy policies, and industrial activity. High-emission countries like China, the United States, and India have seen growing emissions despite increased renewable adoption. The energy sector remains the largest contributor, with coal-fired power plants playing a major role. However, improvements in energy efficiency and the adoption of carbon pricing mechanisms have led to emissions reductions in the European Union and parts of North America.

**4. Energy Intensity and Efficiency**

Energy intensity, measured as energy use per unit of GDP, has declined globally, indicating improved energy efficiency. Developed nations have achieved significant reductions due to energy-saving technologies and stringent policies. However, energy-intensive economies, particularly in manufacturing-driven countries, still face challenges in balancing industrial growth with efficiency improvements. Countries with lower energy intensity, such as Japan and Germany, showcase successful energy conservation models.

**5. Financial Flows into Sustainable Energy**

Investment in clean energy projects has increased, particularly in developing countries. Financial flows to Africa and Asia have grown, with international donors and private investors supporting solar, wind, and hydro projects. Despite this, disparities in investment remain, with high-income nations receiving more funding for advanced technologies, while lower-income nations struggle to attract sufficient capital for large-scale projects.

**6. Economic Growth and Energy Consumption Trends**

The relationship between GDP growth and energy consumption varies across regions. In industrialized economies, economic growth has become less dependent on fossil fuel consumption due to energy efficiency measures and a shift to services-oriented economies. In contrast, emerging economies exhibit a direct correlation between energy use and GDP growth, with increasing energy demands driven by industrialization and urbanization.

**7. Progress Toward Sustainable Development Goal 7 (SDG 7)**

Many countries have made significant progress in achieving SDG 7, particularly in improving electricity access and renewable energy adoption. However, challenges persist, especially in ensuring clean cooking fuel access, where reliance on biomass remains high in parts of Africa and South Asia. While renewable energy investments have grown, energy affordability and reliability remain critical issues for low-income populations.

**8. Developed vs. Developing Countries in Energy Transition**

Developed nations have largely transitioned towards cleaner energy sources, with robust policy frameworks and technological advancements. Developing countries, while making progress, face infrastructure, financial, and policy-related barriers. The disparity in renewable energy adoption and carbon emissions reduction highlights the need for stronger international collaboration and financial support mechanisms to ensure an equitable energy transition.

**9. Off-Grid and Mini-Grid Renewable Solutions**

Decentralized energy solutions, such as mini-grids and solar home systems, have played a crucial role in improving electricity access in remote regions. Countries like Kenya, Bangladesh, and India have pioneered innovative business models for off-grid energy, enabling rural communities to benefit from sustainable electricity without relying on traditional grid expansion. These solutions are vital for accelerating universal energy access.

**10. Government Policies and Their Impact on Energy Transition**

Government policies, including subsidies, tax incentives, and regulatory frameworks, have significantly influenced the pace of energy transition. Nations with strong policy support, such as Germany's Energiewende and China's renewable energy subsidies, have witnessed rapid adoption of clean energy. Conversely, countries with fossil fuel subsidies have faced slower transitions. Policy consistency and long-term commitments are crucial for maintaining momentum toward sustainability.

**The Benefits of Sustainable Energy**

Sustainable energy sources offer several benefits over non-renewable sources, including reduced greenhouse gas emissions, improved air and water quality, and reduced dependence on foreign oil. Additionally, sustainable energy sources like solar and wind power are becoming increasingly cost-competitive with nonrenewable sources, making them more accessible to consumers and businesses.

There are several benefits of sustainable energy, including:

**Reduced carbon emissions:** Reducing carbon emissions is one of the most important benefits of adopting sustainable energy. The use of non-renewable energy sources, such as coal, oil, and natural gas, is a major contributor to greenhouse gas emissions, which are a primary driver of climate change. By transitioning to sustainable energy sources like solar, wind, and hydropower, we can significantly reduce our carbon footprint and slow the pace of climate change. Renewable energy systems produce little to no greenhouse gas emissions during operation, making them a critical tool in reducing our dependence on fossil fuels.

Furthermore, renewable energy systems have a much lower carbon footprint over their entire lifecycle compared to non-renewable energy sources. For example, the production of solar panels and wind turbines requires energy and resources, but these emissions are quickly offset by the clean energy generated by these systems over their lifetime.

In addition to reducing carbon emissions, transitioning to sustainable energy sources can also improve air quality and public health, as non-renewable energy sources often contribute to air pollution and associated health problems.

**Energy security:** Energy security is a term used to describe the availability, accessibility, affordability, and reliability of energy sources for consumers. With sustainable energy sources, such as solar and wind power, becoming more prevalent, there is the potential to reduce reliance on traditional fossil fuels, which are often subject to price fluctuations and supply disruptions. In addition, sustainable energy sources can be harnessed locally, reducing the need for energy imports and increasing energy independence. This can have positive economic impacts, as countries can develop their own sustainable energy industries, creating jobs and stimulating economic growth. Cost savings: Adopting sustainable energy sources can result in significant cost savings for individuals and businesses. While there may be higher initial costs associated with installing renewable energy systems, such as solar panels or wind turbines, over the long term, these systems can generate significant savings by reducing or eliminating the need to purchase electricity from the grid. Additionally, many sustainable energy solutions, such as energy-efficient appliances, can reduce energy consumption, resulting in lower energy bills.

Job creation: The shift towards sustainable energy sources can also have a positive impact on job creation. The renewable energy sector is a growing industry that requires a range of skilled professionals, including engineers, technicians, project managers, and construction workers. According to the International Renewable Energy Agency, the renewable energy sector employed 11.5 million people globally in 2019, and this number is expected to continue to grow in the coming years. In addition, the installation and maintenance of sustainable energy systems often requires local labor, providing job opportunities in communities where these systems are installed.  
Improved public health: Another benefit of sustainable energy is improved public health. The use of fossil fuels for energy production has been linked to a range of negative health impacts, including respiratory problems, heart disease, and cancer. In addition, the extraction and transportation of fossil fuels can result in environmental pollution and the release of harmful chemicals into the air and water. By transitioning to cleaner, renewable energy sources, we can reduce these negative health impacts and improve the overall well-being of communities. For example, the use of electric vehicles powered by renewable energy sources can reduce air pollution and improve air quality in urban areas, leading to improved respiratory health for residents.  
Increased energy access: Another benefit of sustainable energy is increased energy access, particularly in developing countries. Many people in these countries do not have access to reliable sources of energy, which can have a significant impact on their daily lives. Lack of energy access can limit economic opportunities, hinder educational opportunities, and reduce access to basic necessities such as clean water and healthcare. Sustainable energy solutions, such as off-grid solar panels and mini-grids, can provide reliable and affordable access to electricity, improving the quality of life for millions of people. Additionally, the use of sustainable energy in these communities can reduce reliance on expensive and polluting fossil fuels, which can have long-term economic and environmental benefits.

### ****Challenges****

#### **1. High Initial Costs**

* **Renewable Energy Infrastructure:** Establishing solar farms, wind turbines, hydroelectric plants, and geothermal facilities requires significant upfront investment.
* **Financial Barriers for Developing Nations:** Many developing countries struggle to secure funding for large-scale renewable energy projects, leading to slow adoption.
* **Cost of Grid Expansion:** Expanding electricity access, especially in rural and remote areas, involves high capital costs for transmission and distribution networks.
* **Financial Flows:** Despite financial aid, many developing nations still face a gap in investments required to transition to clean energy.

#### **2. Technological Limitations**

* **Intermittency of Renewable Energy:** Solar and wind energy depend on weather conditions, making them less reliable without advanced storage solutions.
* **Energy Storage Issues:** Efficient, large-scale battery storage remains expensive and underdeveloped in many regions, limiting renewable energy integration.
* **Limited Grid Flexibility:** Many countries still rely on outdated grid infrastructure that cannot efficiently integrate variable renewable energy sources.
* **Research and Development Gaps:** Advanced renewable technologies, such as next-generation biofuels and enhanced geothermal systems, remain costly and underfunded.

#### **3. Regulatory Barriers**

* **Inconsistent Energy Policies:** Some countries lack stable and long-term policies supporting renewable energy development, discouraging private investment.
* **Subsidies for Fossil Fuels:** Many nations continue to provide subsidies for coal, oil, and gas, making it harder for renewables to compete economically.
* **Complex Permitting Processes:** Lengthy and bureaucratic approval processes delay the implementation of renewable energy projects.
* **Lack of Standardized Regulations:** Varying grid connection policies and renewable energy incentives across nations create uncertainty for investors.

#### **4. Infrastructure Limitations**

* **Weak Transmission Networks:** Many regions, particularly in Africa and South Asia, have insufficient transmission capacity to support large-scale renewable energy deployment.
* **Limited Electrification in Rural Areas:** Despite progress, access to electricity remains low in many developing countries, hindering economic development.
* **Aging Fossil Fuel Infrastructure:** Many nations still depend on decades-old coal and oil power plants, making a transition to renewables costly.
* **Challenges in Integrating Mini-Grids:** While off-grid solutions help expand electricity access, they often lack integration with national grids, limiting scalability.

#### **5. Lack of Public Awareness**

* **Energy Efficiency Knowledge Gaps:** Many individuals and businesses are unaware of cost-saving energy efficiency measures.
* **Misconceptions About Renewable Energy:** Public skepticism about the reliability and affordability of renewables slows adoption.
* **Resistance to Change:** Traditional energy industries and their workforce may resist the transition to renewables due to job security concerns.
* **Education and Advocacy Deficits:** Insufficient government and media efforts to educate communities on the benefits of clean energy.

### ****Impacts on Sustainable Energy Indicators****

These challenges affect key indicators such as:

* **Electricity Access:** Limited infrastructure and high costs slow progress in achieving universal energy access.
* **Renewable Energy Share:** Fossil fuel subsidies and grid limitations hinder the growth of renewables in the energy mix.
* **Carbon Emissions:** Continued reliance on fossil fuels results in high emissions, delaying climate goals.
* **Energy Intensity:** Developing nations struggle to improve energy efficiency due to outdated industrial processes.
* **Financial Flows:** Insufficient funding in low-income nations creates disparities in energy transitions.
* **Economic Growth:** Dependence on fossil fuels can lead to economic volatility, particularly in oil-exporting countries.

By comparing nations, tracking progress toward Sustainable Development Goal 7, and analyzing global trends, we can identify opportunities for overcoming these barriers and accelerating the shift toward sustainable, inclusive, and low-carbon energy systems.

**Conclusion:**

This report on The global data on sustainable energy from 2000 to 2020 provides invaluable insights into the complex interplay of electricity access, renewable energy adoption, carbon emissions, energy intensity, financial flows, and economic growth across nations. The period reveals significant progress in many regions, particularly in improving electricity access and expanding the share of renewable energy in the global energy mix. However, challenges such as high initial costs, technological limitations, regulatory barriers, infrastructure shortcomings, and public awareness gaps continue to hinder the full realization of a sustainable energy future. While developed nations have largely transitioned to cleaner energy sources, developing countries face ongoing struggles due to financial and infrastructure constraints. Moreover, the growing demand for energy in emerging economies, coupled with the persistence of fossil fuel subsidies and outdated energy infrastructure, complicates efforts to achieve the goals set by Sustainable Development Goal 7. Tracking progress over two decades highlights both successes and critical disparities, underlining the need for increased international cooperation, financial support, and policy consistency to accelerate the global energy transition. Addressing these challenges is essential for fostering a low-carbon, equitable energy future and ensuring that sustainable energy becomes a reality for all.

**Research Questionnaire**

1.What is the average access to electricity (% of population) across different countries/entities over the years?

2.How does electricity generation from renewables (TWh) compare to fossil fuels (TWh) across countries/entities?

3. What is the trend in financial flows to developing countries (US $) over the years, and how does it relate to renewable electricity capacity per capita (kW/person)?

4. Which countries has the highest average energy intensity (MJ/$2017 PPP GDP) across all countries/entities?

5. How does access to clean fuels for cooking correlate with CO2 emissions (kt) by country/entity?

6. How does the primary Renewable energy per capita (kWh/person) of the country/entity with the highest consumption compare to that of the country/entity with the lowest, in terms of ratio?

7. What is the relationship between population density (P/Km²) and renewable electricity generation per capita (kW/person)?

8. What is the average percentage of low-carbon electricity (% of total electricity) across different countries/entities?

9. How do financial flows to developing countries (US $) vary with GDP per capita across different countries/entities?

10. What is the distribution of primary energy consumption per capita (kWh/person) among the top 5 energy-consuming countries?

**References**

Jaiswal, K. K., Chowdhury, C. R., Yadav, D., Verma, R., Dutta, S., Jaiswal, K. S., & Karuppasamy, K. S. K. (2022). Renewable and sustainable clean energy development and impact on social, economic, and environmental health. *Energy Nexus*, *7*, 100118.

International Energy Agency. (2021). World energy outlook 2021. IEA. https://www.iea.org/reports/world-energy-outlook-2021

United Nations. (2021). Tracking SDG 7: The energy progress report. World Bank. https://trackingsdg7.esmap.org/

International Renewable Energy Agency. (2020). Global renewables outlook: Energy transformation 2050. IRENA. https://www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020

World Bank. (2021). Sustainable energy for all database. World Bank. <https://databank.worldbank.org/source/sustainable-energy-for-all>