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Review Article

Energy, Economic and Environmental Scenario and Race to Low-Carbon Economy among BRICS Countries

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ABSTRACT
There has been a concentration on the current energy, economic, and environmental situation among the BRICS countries. When it comes to energy, the environment, and economics, China and India are at the top. Here is a correlation coefficient matrix that includes all BRICS countries: population size, GDP, primary energy consumption, and CO_2 equivalent emissions. All five BRICS countries and the BRICS group as a whole have taken stock of their climate action efforts and compared them to those of the globe, the G20, and the OECD. In every category, India has performed better than any of the other BRICS countries and the globe at large. As a whole, the BRICS forum's performance on climate action has been greatly enhanced by the efforts of India and Brazil. On the whole, the BRICS forum outperforms the G20 and the OECD. In order to achieve a low-carbon economy, the BRICS nations have concentrated their efforts, strategies, and initiatives

1. Introduction

A. Energy, Economy, Environment and Climate

Because it is a necessary component in the production of nearly all modern economic goods and services, energy is the fundamental fuel that keeps the world economy turning. Jobs and values created by the extraction, transformation, and distribution of energy directly contribute to economic growth and development. There is a one-to-one relationship between the pace of energy consumption and the rate of economic growth. Research has shown that power supply has to rise at roughly 12% per year for GDP to grow at 8% per annum. This indicates that power demand is outpacing GDP growth [1-5].

There may be environmental impacts associated with energy sources in all their stages: generation, transmission, and consumption. To meet the climate targets set out in Paris, carbon dioxide removal is an absolute must.

Under the Paris Agreement, signatories pledge to do their best "to limit the temperature increase to 1.5°C above pre-industrial levels" and keep "the increase in the global average temperature to well below 2°C above pre-industrial levels."

B. BRICS Countries

The BRICS group of fast-growing economies consists of South Africa, Brazil, Russia, India, and China[6-10]. When it comes to global economic affairs, they are pivotal players. An worldwide credo for creating energy-based sustainable development, the Energy Research Co-operation Platform (ERCP) of BRICS countries is a powerful tool. These nations have been cooperating on educational programs, exchanging statistical data, and planning the expansion of their national energy systems and energy-related best practices and regulatory frameworks through the Energy Regional Cooperation Program (ERCP).

C. Need for Low Carbon Economy (LCE)

Numerous advantages accrue to ecosystem adaptability, commerce, employment, health, energy stability, and industrial efficiency in low-carbon economies. Roughly 81% of the energy consumption comes from fossil fuels [11-15]. A certain amount of climate change is now assured due to the impact of human activities on the globe. We are now facing a temperature increase of 3–5 degrees Celsius, although there is still time to keep it below 2 degrees Celsius. In order for this to take place, we need to eliminate all net emissions of greenhouse gases by the century's end. It will be difficult, but not impossible, to achieve this objective. In order to combat climate change and reach zero net emissions, all governments should form an authentic international alliance.

1.1 Objectives, Data and Methodology of the Study

The study's overarching goals are (a) to assess the current economic, energy, and environmental situation, and (b) to identify the ways in which the BRICS nations may use renewable energy to reach their goal of zero net emissions. Secondary data for the study came from a variety of places, including (a) Enerdata 2022, World Energy Information, (b) Macrotrends (n.d.), (c) the Energy Institute's World Energy Statistical Review 2023, (d) bp Energy Outlook 2023, and many more. The document is structured into six parts: 1. Background, 2. Literature Review, 3. The Current BRIC Economic, Energy, and Environmental Situation, 4. Efforts to Reach a Low-Carbon Economy in the BRICS Countries: Revised Strategies and Objectives 6. Restrictions and Ways Forward for Research, and 5. Final Thoughts and Policy Suggestions. Tables, percentages, compounded annual growth rates (CAGRs), and other visualizations have been used to show the data.

Using t-tests, we produced a matrix of correlation coefficients between population size, GDP, primary energy consumption, CO2 equivalent emissions from energy processes, methane, and flaring, and primary energy consumption.

At 2011 prices, the energy intensity level of primary energy was defined as the ratio of energy supply to gross domestic product at purchasing power parity. The energy intensity of a process is defined as the amount of energy required to generate one unit of economic output. If the ratio is low, then less energy is required to provide the same amount of output. Megajoules (MJ) per$ of GDP is the unit of energy intensity.

2. Review of Literature

The following points were made by Sahu (2016): (a) the BRICS nations' joint efforts to advance the energy sector while simultaneously addressing pressing global issues like climate change, (b) the BRICS nations' impact on the world economy, and (c) their partnership with the International Energy Agency.

Maryam et al. (2017) used the yearly data set from 1991 to 2011 to look for a correlation between three variables: carbon dioxide emissions, economic growth rate (per capita GDP), and energy consumption in the BRICS nations. According to the research, the BRICS nations must work together closely to lessen the impact of climate change. Investment in environmentally friendly initiatives was necessary to enhance economic development and pave the way for sustainable development.

The transition to a low-carbon economy in South Africa has forced the country to seek out new ways to generate power, as pointed out by Adedeji et al. (2020). In light of the impending shift to a low-carbon economy, the research examined the current status of South Africa's renewable energy system with an eye toward improved energy accessibility and sustainability. In order to better understand South Africa, we looked at case studies from other countries. Presentation of data was done using various visual aids such as tables and charts.

Based on data collected from the Climate Action Tractor (CAT) database, Cai et al. (2021) analyzed the policies, plans, and programs of the BRICS countries that are fighting climate change through LCE promotion. They suggested that the BRICS countries should expand low-carbon investments and financing, invest in low-carbon cities, adapt to a circular economy and low-carbon technology, revisit electricity markets, and promote climate-friendly international trade.

Gupta et al. (2021) utilized a hybrid modeling architecture that merges the strengths of the AIM/Enduse bottom-up model of Indian energy systems with the IMACLIM top-down economy-wide model of India to investigate the macroeconomic effects of attaining development via low-carbon routes. Our business-as-usual scenario has large investment costs, but the study showed that low-carbon scenarios could handle 5.8% annual economic growth from 2013 to 2050. Tables and charts were used to display the results.

It was noted by Basso et al. (2022) that the BRICS group was not a coherent alliance when it came to international climate politics. Their article analyzed emissions profiles, primary policies to reduce emissions, and foreign policy stances of each BRICS country from 1990 to 2019 using data gathered from SEEG (2022), Climate Watch Data (2022), and the World Bank (2022). Data was shown in a tabular format.

Based on real GDP per capita as a proxy for a country's level of development, Dey et al. (2022) analyzed how the energy mix evolved over time. When it comes to renewable energy, India's market is the world's fourth most promising. The Indian government is actively pushing green energy and is involved in a number of large-scale sustainable power projects to increase the use of clean energy. The article provided a high-level overview of the current state of, and potential future developments in, the field of sustainable development and renewable energy. Tables and charts had been used to display the data.

A Green Economy Index was introduced by Nguyen et al. (2023) to assess the BRICS nations' green economies. The index is based on three criteria: environmental impact, economic growth, and the standard of green living. According to the research, the BRICS countries are starting to care more about issues like equality, social welfare, and the environment, rather than just economic growth. Tables and charts were used to display the results.

Identification of Research Gap

A thorough examination of the relevant literature has revealed a dearth of research in the current field. The majority of the studies that were reviewed relied on descriptive statistics such as percentages, tables, and averages rather than conducting in-depth research on the following topics: (a) the current energy, economic, and environmental situation; and (b) the initiatives that the BRICS countries have implemented and their potential for achieving a low-carbon economy. Here is a matrix of correlation coefficients for a number of relevant economic, energy, ecological, and demographic variables

3. Present Economic, Energy and Envionmental Scenario among the BRICS Countries

A larger population is positively associated with higher levels of energy consumption and pollution. The BRICS countries' population sizes for the years 2018–22 are presented in Table 1:-

Table 1. Population Sizes (in Crores) for BRICS Countries for 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
India	136.90	138.31	139.64	140.76	141.71	0.87	1
China	140.03	140.77	141.11	141.24	141.22	0.30	2
Brazil	21.02	21.18	21.32	21.43	21.53	0.60	7
Russia	14.45	14.44	14.41	14.34	14.36	-0.16	9
South Africa	5.73	5.81	5.88	5.94	5.99	1.12	24

Source: Macrotrends (n.d.)
*Calculated by Authors

The correlation between energy consumption and pollution levels is strong, and GDP, a measure of economic growth and

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development, is even stronger. In Table 2 you can see the BRICS countries' GDP for 2018 and 2018.

Table 2. GDP (Nominal) (Trillion $) for BRICS Countries for 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
China	13.895	14.280	14.688	17.820	17.963	6.63	2
India	2.703	2.836	2.672	3.150	3.385	5.79	5
Russia	1.657	1.693	1.493	1.837	2.240	7.83	8
Brazil	1.917	1.873	1.476	1.650	1.920	0.04	11
South Africa	0.404	0.389	0.338	0.419	0.406	0.12	37

Source: Macrotrends (n.d.)
*Calculated by Authors

Both energy usage and pollution levels are strongly correlated with GDP per capita. In Table 3 you can see the BRICS countries' GDP per capita from 2018 to 22.

Table 3. GDP Per Capita (Nominal) ($) for BRICS Countries for 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22
Russia	11,287	11.536	10,194	12.593	15,345	7.98
China	9,905	10,144	10,409	12,618	12,720	6.45
Brazil	9,121	8,845	6,925	7,697	8,918	-0.56
South Africa	7,049	6,689	5,742	7,055	6,776	-0.98
India	1,974	2,050	1,913	2,238	2,389	4.89

Source: Macrotrends (n.d.)
*Calculated by Authors

All energy products that are not converted, directly utilized, or imported are considered primary energy. Materials such as crude oil, oil shale, natural gas, biomass, solar radiation, hydraulic energy, wind energy, geothermal energy, and uranium fission energy are mostly included. For the years 2018–22, Table 4 details the BRICS countries' primary energy consumption, while Table 5 details their primary energy consumption per capita.

Table 4. Primary Energy Consumption (in Exajoules) for BRICS Countries for 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	12.51	12.72	12.22	12.85	13.41	1.75	7
Russia	30.39	30.16	29.07	31.48	28.89	-1.26	4
South Africa	5.11	5.33	4.99	5.00	4.82	-1.45	25
China	138.30	144.74	149.45	157.94	159.39	3.61	1
India	32.69	33.52	31.76	34.51	36.44	2.75	3

Source: Energy Institute (2023)
*Calculated by Authors

World energy consumption growth fell to half in 2022, with China's consumption growth also slowing, in line with overall world economic rising patterns.

Table 5. Primary Energy Consumption (in Gigajoules) Per Capita for BRICS Countries for 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22
Brazil	59.5	60.1	57.3	60.0	62.3	1.16
Russia	208.6	207.0	199.6	217.0	199.7	-1.08
South Africa	89.1	91.8	84.8	84.2	80.5	-2.51
China	97.6	101.8	104.9	110.8	111.8	3.45
India	23.9	24.2	22.7	24.5	25.7	1.83

Source: Energy Institute (2023)
*Calculated by Authors

CO_2 equivalent emissions from energy, process emissions, methane and flaring for the BRICS countries for the years 2018-22 have been provided in Table 6.

Table 6. CO_2 Equivalent Emissions (Million Tonnes of CO_2 Equivalent) from Energy, Process Emissions, Methane and Flaring for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	498.0	494.3	469.2	524.0	506.0	0.40	12
Russia	2138.6	2141.3	2014.2	2175.2	2024.0	-1.37	4
South Africa	490.9	513.1	483.6	473.6	456.2	-1.82	13
China	10876.1	11258.1	11499.7	11969.3	11876.9	2.23	1
India	2613.2	2645.4	2450.3	2700.5	2865.6	2.33	3

Source: Energy Institute (2023)
*Calculated by Authors

Table 7 displays the correlation coefficient matrix for all BRICS countries, including population size, GDP, primary energy consumption, and CO2 equivalent emissions. The significance of all correlation coefficients was determined using t tests, and the results were significant (P-Value < 0.001).

Table 7. Correlation Coefficient Matrix* of Population Size, GDP, Primary Energy Consumption and CO_2 Equivalent Emissions taking all BRICS Countries

	Population Size	GDP	Primary Energy Consumption	CO_2 Equivalent Emissions
Population	1	0.697	0.709	0.723

Size				
GDP		1	0.991	0.986
Primary Energy Consumption			1	0.998
CO_2 Equivalent Emissions				1

*Calculated by Authors

Renewable energy consumption (in exajoules Input-equivalent) for the BRICS countries for the years 2018-22 has been provided in Table 8.

Table 8. Renewable Energy Consumption (in Exajoules Input-equivalent) for BRICS Countries for Years 2018-22 (Figures in Brackets indicate % of Renewable Energy Consumption in Respect to Primary Energy Consumption)

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	1.98 (15.83)	2.18 (17.14)	2.20 (18.00)	2.36 (18.37)	2.53 (18.87)	6.32	3
Russia	0.02 (6.58)	0.02 (6.63)	0.04 (13.76)	0.06 (19.06)	0.08 (27.69)	41.42	47
South Africa	0.11 (2.15)	0.12 (2.25)	0.12 (2.40)	0.15 (3.00)	0.16 (3.32)	9.82	34
China	6.37 (4.61)	7.38 (5.10)	8.52 (5.70)	11.27 (7.14)	13.30 (8.34)	20.21	1
India	1.31 (4.01)	1.48 (4.42)	1.58 (4.97)	1.82 (5.27)	2.15 (5.90)	13.19	5

Source: Energy Institute (2023)
*Calculated by Authors

In 2022, renewable energy consumption continued to rise across the board for the BRICS countries. Russia generated very little renewable energy in 2022.

Table 9 shows the BRICS countries' coal consumption (in exajoules) from 2018 to 22.

Table 9. Coal Consumption (in Exajoules) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	0.69	0.65	0.59	0.71	0.59	-3.84	22
Russia	3.63	3.57	3.29	3.43	3.19	-3.18	7
South Africa	3.53	3.76	3.66	3.51	3.31	-1.60	6
China	80.47	82.52	84.25	87.54	88.41	2.38	1
India	17.93	17.96	16.97	19.30	20.09	2.88	2

Source: Energy Institute (2023)
*Calculated by Authors

In 2022, coal usage declined in all BRICS nations with the exception of India and China.

Table 10 displays the BRICS countries' natural gas consumption (in exajoules) from 2018 to 22.

Table 10: Natural Gas Consumption (in Exajoules) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	1.29	1.29	1.13	1.46	1.15	-2.83	29
Russia	16.36	16.00	15.25	17.09	14.69	-2.66	2
South Africa	0.16	0.15	0.14	0.17	0.16	0.00	66
China	10.22	11.10	12.12	13.69	13.53	7.27	3
India	2.09	2.13	2.17	2.24	2.09	0.00	15

Source: Energy Institute (2023)
*Calculated by Authors

In 2022, natural gas consumption in China increased while in Brazil and Russia it decreased; in South Africa and India, it hardly changed.

You can find the BRICS countries' oil consumption (in exajoules) for the years 2018–22 in Table 11.

Table 11. Oil Consumption (in Exajoules) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	4.71	4.69	4.42	4.78	5.01	1.56	8
Russia	6.70	6.3	6.52	6.88	7.05	1.28	4
South Africa	1.19	1.18	0.96	1.04	1.06	-2.85	36
China	27.12	28.49	28.74	29.52	28.16	0.95	2
India	9.68	9.99	9.07	9.25	10.05	0.94	3

Source: Energy Institute (2023)
*Calculated by Authors

Among the BRICS nations, oil consumption was on the rise in 2022, with the exception of South Africa, which saw a decline.

The demand for oil is falling because fewer people are using road transportation. Oil and natural gas production in Russia fell as a result of the conflict (bp, 2023). Table 12 displays the hydroelectricity usage (in exajoules) of the BRICS nations from 2018 to 22.

Table 12: Hydroelectricity Consumption (in Exajoules) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	3.70	3.78	3.75	3.72	4.00	1.97	2
Russia	1.82	1.84	2.01	2.02	1.90	1.08	5
South Africa	0.65	0.65	0.69	0.73	0.70	1.87	7
China	11.42	12.08	12.50	12.25	12.23	1.73	1
India	1.33	1.54	1.55	1.51	1.64	5.38	6

Source: Energy Institute (2023)
*Calculated by Authors

In 2022, the BRICS nations' usage of hydroelectricity rose. When compared to the other BRICS countries, India's CAGR was the highest.

For the years 2018–22, Table 13 provides the BRICS countries' nuclear energy consumption, measured in exajoules input-equivalent.

Table 13. Nuclear Energy Consumption (in Exajoules Input-equivalent) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	0.14	0.15	0.13	0.13	0.13	-1.84	24
Russia	1.87	1.90	1.96	2.01	2.01	1.82	4
South Africa	0.11	0.12	0.09	0.11	0.09	-4.89	27
China	2.70	3.18	3.32	3.68	3.76	8.63	2
India	0.36	0.41	0.40	0.40	0.42	3.93	12

Source: Energy Institute (2023)
*Calculated by Authors

Except for South Africa and Brazil, all of the BRICS nations had increases in their nuclear energy usage in 2022. This is an area where South Africa and Brazil saw declining trends.

Table 14 shows the BRICS countries' consumption of renewable energy biofuels (in thousand barrels of oil equivalent per day) for the years 2018-22.

Table 14. Renewable Energy Biofuels Consumption (in Thousand Barrels of Oil equivalent per Day) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	385	426	396	392	390	0.32	2
Russia	----	----	----	----	----	----	----
South Africa	----	----	----	----	----	----	----
China	49	37	45	45	45	-0.02	6
India	33	37	36	51	58	15.14	5

Source: Energy Institute (2023)
*Calculated by Authors

In 2022, India's consumption of renewable energy biofuels continued to rise, indicated by the number of thousand barrels of oil equivalent per day.

According to bp (2023), modern bioenergy is quickly growing and helping to decarbonize industries and processes that are difficult to tackle.

Table 15 displays the renewable energy biofuels output for the BRICS countries from 2018 to 2022, expressed as thousand barrels of oil equivalent per day.

Table 15: Renewable Energy Biofuels Production (in Thousand Barrels of Oil equivalent per Day) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	401	429	411	391	409	0.50	2
Russia	----	----	----	----	----	----	----
South Africa	----	----	----	----	----	----	----
China	44	53	56	58	66	0.11	4
India	19	21	23	35	43	0.23	8

Source: Energy Institute (2023)
*Calculated by Authors

In 2022, the output of renewable energy biofuels from Brazil, China, and India continued to rise, measured in thousand barrels of oil equivalent per day.

For the years 2018–22, Table 16 displays the BRICS countries' electricity generation in terawatt-hours.

Table 16. Electricity Generation (in Terawatt-hours) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	601.4	633.3	628.8	656.1	677.2	3.01	6
Russia	1109.2	1118.1	1085.4	1157.1	1166.9	1.28	4
South Africa	256.3	252.6	239.5	244.3	234.8	-2.17	23
China	7166.1	7503.4	7779.1	8534.3	8848.7	5.37	1
India	1579.2	1622.1	1581.9	1714.8	1858.0	4.15	3

Source: Energy Institute (2023)
*Calculated by Authors

There were upward trends of electricity generation among BRICS countries except South Africa in 2022.

Electricity generation (in terawatt-hours) by fuel for the BRICS countries in 2022 has been provided in Table 17.

Table 17. Electricity Generation (in Terawatt-hours) by Fuel for BRICS Countries in 2022 (Figures in Brackets indicate Percentages*)

Country	Oil	Natural Gas	Coal	Nuclear Energy	Hydro Electricity	Renewables	Others	Total
Brazil	10.1 (1.49)	42.1 (6.22)	16.5 (2.44)	14.6 (2.16)	427.1 (63.07)	164.5 (24.28)	2.3 (0.34)	677.2 (100)

Russia	6.7 (0.57)	533.9 (45.75)	192.3 (16.48)	223.7 (19.17)	197.7 (16.94)	7.4 (0.63)	5.3 (0.46)	1166.9 (100)
South Africa	3.6 (1.53)	----	197.2 (83.99)	10.1 (4.30)	3.1 (1.32)	16.3 (6.94)	4.5 (1.92)	234.8 (100)
China	11.9 (0.13)	290.6 (3.28)	5397.8 (61.00)	417.8 (4.72)	1303.1 (14.73)	1367.0 (15.45)	60.4 (0.69)	8848.7 (100)
India	2.5 (0.13)	47.0 (2.53)	1380.1 (74.28)	46.2 (2.49)	174.9 (9.41)	205.9 (11.08)	1.4 (0.08)	1858.0 (100)

Source: Energy Institute (2023)
*Calculated by Authors

Alternative energy sources, including nuclear power and renewables like solar, wind, and hydropower, can generate low-carbon electricity. Brazil, Russia, China, India, and South Africa were the only BRICS nations in 2022 with low-carbon energy generation accounts for around 90%, 38%, 36%, 23%, and 14% of total generation, respectively.

In the instances of South Africa, China, and India, coal accounts for the vast majority of the electricity generated. When it comes to Brazil and Russia, hydroelectricity and natural gas are the two main players when it comes to power generation.

In Table 18 you can see the BRICS countries' renewable energy generation in terawatt-hours broken down by source for the year 2022.

Table 18. Renewable Energy Generation (in Terawatt-hours) by Source for BRICS Countries in 2022 (Figures in Brackets indicate Percentages*)

Country	Wind	Solar	Other Renewables	Total
Brazil	81.6 (49.60)	30.1 (18.30)	52.8 (32.10)	164.5 (100)
Russia	4.2 (56.76)	2.4 (32.43)	0.8 (10.81)	7.4 (100)
South Africa	9.7 (59.51)	6.2 (38.04)	0.4 (2.45)	16.3 (100)
China	762.7 (55.79)	427.7 (31.29)	176.6 (12.92)	1367.0 (100)
India	70.0 (34.00)	95.2 (46.24)	40.7 (19.76)	205.9 (100)

Source: Energy Institute (2023)
*Calculated by Authors

With the exception of India, all of the BRICS countries rely on wind power as their primary renewable energy source. In the case of India, solar power constitutes the majority of renewable energy sources.

A dramatic quickening of the pace of renewable energy funding and construction is necessary because to the rapid expansion of wind and solar power (bp, 2023). Table 19 displays the renewable energy data for the BRICS countries from 2018 to 2022 in terms of installed photovoltaic (PV) power, expressed in megawatts.

Table 19. Renewable Energy Solar – Installed Photovoltaic (PV) Power (in Megawatts) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	2435	4635	8291	14197	24079	77.33	8
Russia	535	1276	1428	1661	1816	35.73	42
South Africa	4805	4908	5995	6316	6326	7.18	21
China	175263	205060	254055	307068	393127	22.38	1
India	27453	35203	39385	49684	63146	23.15	4

Source: Energy Institute (2023)
*Calculated by Authors
Megawatts
Megawatts

Solar photovoltaic (PV) installations as a source of renewable energy increased in 2022 across the BRICS nations. The BRICS nations with the highest CAGR were Brazil and Russia.

Wind power, specifically the capacity of installed wind turbines in megawatts, for the BRICS nations from 2018 to 22 is presented in Table 20.

Table 20. Renewable Energy Wind – Installed Wind Turbine Capacity (in Megawatts) for BRICS Countries for Years 2018-22

Country	2018	2019	2020	2021	2022	CAGR (%)* over 2018-22	Global Rank in 2022
Brazil	14843	15438	17198	21161	24163	12.96	10
Russia	52	102	945	1955	2218	155.56	36
South Africa	2094	2094	2516	2956	3103	10.33	32
China	184666	209583	282113	328974	365965	18.65	1
India	35288	37505	38559	40067	41930	4.41	4

Source: Energy Institute (2023)
*Calculated by Authors
Megawatts
Megawatts

Among the BRICS nations, wind turbine capacity for renewable energy installations was on the rise in 2022. Russia outpaced all of the BRICS nations in terms of CAGR. See Table 21 for BRICS nations' energy intensity in 2020 and (b) CO2 equivalent emissions per capita in 2022, as well as their energy independence and rate of T&D power losses.

Table 21. (a) Energy Intensity, (b) For 2022, CO_2 Equivalent Emissions Per Capita (Tonnes), Energy Independence and Rate of T&D Power Losses for BRICS

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Country	Energy Intensity (MJ per $ of GDP)[a]	CO_2 Equivalent Emissions Per Capita[b] (Tonnes)	Energy Independence[c] (%)	Rate of T&D Power Losses[c] (%)
Brazil	4	2.35	100.0	14.9
Russia	8	14.09	100.0	9.46
South Africa	7	7.62	100.0	12.0
China	6	8.41	81.9	4.52
India	4	2.02	65.0	17.9

Source: [a]Knoema (n.d.), [c]Enerdata (2022).
[b]Calculated by Authors

Russia has the highest energy intensity and CO_2 equivalent emissions among the BRICS countries. Brazil, Russia, and South Africa are energy independent. Brazil also has the highest rate of technology and development power losses. Carbon trading markets were considered as a potential solution by the BRICS countries to achieve their objective of reducing carbon emissions. But there have been many obstacles along the way, including market regulation and supervision, funding and assistance, technical capacity building, public engagement and information dissemination, and striking a balance between economic growth and environmental preservation (Zhang, 2023). The BRICS members acknowledged the importance of working together in a communiqué adopted at the BRICS Energy Ministers Meeting in New Delhi, India on September 2, 2021. The goal is to move towards more efficient and cleaner energy systems that promote inclusive growth, reduce emissions of greenhouse gases, and guarantee affordable, reliable, accessible, and sustainable energy. In order to ensure energy security, they recognized the significance of a diverse energy mix, better infrastructure, and technology advancements. They reaffirmed their intentions to foster collaboration in various domains, such as the advancement of renewable, nuclear, hydrogen, advanced bioenergy, and other energy options with low or zero emissions, as well as the more efficient utilization of fossil fuels. In addition, they made a pact to work on building up their Carbon Capture, Utilization, and Storage (CCUS) capabilities and implementing the Circular Carbon Economy (CCE) strategy.

We have taken stock of the climate action landscape and compared our progress using five key indicators. These include: (a) the average yearly mean surface temperature change from 2016 to 2019 in degrees Celsius, (b) the per capita greenhouse gas emissions from 2018 to 2019, (c) the per capita CO_2 emissions from fuel consumption in production in 2019 to tonnes, (d) the effective proportion of coal powered energy in 2019 to %, and (e) the BRICS group's performance relative to the G20, the OECD, and the rest of the world. Table 22 presents a snapshot of the BRICS countries' climate action performance according to five variables.

Table 22. Performance of BRICS Nations on Five Indicators

Country	Indicator				
	Average Values of Annual Mean Surface Temperature Change (2016-19 in °C)	Per Capita GHG Emissions (2018 in Tonnes)	Per Capita CO_2 emissions from Fuel Consumption as Part of Production (2019 in Tonnes)	Proxy Indicative of Effective Expenditure Incurred on Carbon Savings (2019 Unit Free)	Effective Proportion of Coal Powered Energy (2019 in %)
BRICS Members					
Brazil	1.38500	6.78	2.301797	0.000609	-1.95
Russia	2.21575	13.79	11.63003	0.000785	81.50
South Africa	0.90600	2.47	1.92179	0.013908	-99.40
China	1.47725	8.40	7.505098	0.000500	95.50
India	1.43225	9.01	8.127334	-14.262300	99.00
Forum and The World					
BRICS	1.48	8.49	4.96	0.000565	58.7
G20	1.38	9.10	6.08	0.000150	66.2
OECD	1.41	9.15	9.04	0.000126	77.1
World	1.47	6.49	4.78	0.000539	43.9

Source: D'Souza (2022).

In every category, India has performed better than any of the other BRICS countries and the globe at large. When looking at the BRICS forum's overall record in climate action, India and Brazil both make strong positive contributions. Aside from Russia, the other BRICS countries have also underperformed relative to their peers and the global average. With the exception of one metric, the BRICS forum outperformed the G20 and the OECD in terms of aggregate performance. This metric measures the average values of the yearly mean surface temperature change.

4. Initiatives Adapted, Plans and Scopes for Achieving Low Carbon Economy among the BRICS Countries

India

During the 27th Conference of Parties (COP27) in Egypt from June 6th to the 18th, 2022, India presented its Long-Term Low Emission Development Strategy to the UNFCCC. Here are a few key aspects of the strategy:–

(a) Energy security would be a primary concern while we work to maximize the efficient use of our nation's resources. There would be an orderly, long-term, and inclusive shift away from fossil fuels. Launched in 2021, the National Hydrogen Mission would strive to transform India into a sustainable hydrogen center. Other goals for the power sector's future include tripling nuclear capacity by 2032, boosting the country's capacity to manufacture electrolyzers, and speeding up the generation of green hydrogen.

(b) The transportation sector is expected to see low-carbon development due to the following factors: the growing use of biofuels, particularly ethanol blended with gasoline, the push to boost the penetration of electric vehicles, and the rising use of green hydrogen fuel. One of India's long-term goals is to have 20% of its fuel come from ethanol by 2025, with another is to have a significant increase in the usage of public transportation for both people and goods.

(c) The focus would be on improving energy efficiency by the Perform, Achieve and Trade (PAT) scheme, National Hydrogen Mission, high level of electrification in all relevant processes and activities, enhancing material efficiency and recycling leading to expansion of circular economy, and exploring options for hard-to-abate sectors etc.

India has 4% of the world's freshwater resources and 2.45 percent of the Earth's surface area. Great potential exists for hydroelectricity in India's water resources. The Indian subcontinent is home to vast quantities of uranium, thorium, beryllium, lithium, zirconium, and other atomic minerals. Atomic minerals are a relatively new energy source that has the potential to replace coal, mineral oil, and hydroelectricity. India is currently in the early stages of developing its geothermal power producing capacity. India is home to approximately 340 geothermal hot springs, according to the country's Geological Survey. A lot of renewable energy sources, like sun and wind, are available in India. As far as thorium possessions go, India is #1 in the world. Solar power would account for 100 GW, biopower for 10 GW, wind power for 60 GW, and small hydropower facilities for 5 GW of India's planned 175 GW of renewable energy by 2022. Over and above the lofty goals, investors have pledged to reach 270 GW.

Currently, the nation's ability to produce hydrogen from renewable sources is somewhat limited. Several organizations have declared their intention to set up Green Hydrogen/Green Ammonia manufacturing facilities in India.

An enormous economic potential exists in the transition to renewable energy. Renewable batteries and green hydrogen are two areas where India has a great chance to become an international leader. As a result of these and similar low-carbon technology, India's market for them would reach $80 billion by the year 2030.

China

A detailed plan to speed up China's expansion of renewable energy (RE), the 14th Five-Year Plan (FYP) on Renewable Energy Development (2021–2025) was issued by the Chinese government in June 2022. For the years 2021–2025, the plan called for half of China's additional power and energy consumption to originate from renewable sources, and it aimed to double renewable energy generation from 2.2 trillion kWh in 2020 to 3.3 trillion kWh in 2025. The plan also set a target for renewable electricity consumption share of 33 percent in 2025, up from 28.8 percent in 2020. If the plan's objectives are met, 2.6 gigatonnes of carbon dioxide would be reduced per year, which is about a quarter of China's total carbon emissions in 2020.

Nearly six percent of the world's freshwater supplies are located in China, the world's third-largest country. The Chinese water industry stands to gain from a shift toward renewable energy sources in the power sector.

According to the Information Library (n.d.), China intends to acquire one third of its uranium from international joint ventures and mines, produce one third domestically, and use the other third to fund its domestic production.

Among the world's most extensive thorium reserves is located in China. Although the precise amount of these reserves has remained undisclosed, it is believed that they can fulfill the nation's energy demands for almost twenty thousand years.

Geothermal resources have the benefit of local development and consumption because they are abundant in China and dispersed mostly in the eastern region, which has the highest energy demand. China lies inside the geothermal zones of both the circum-Pacific and Himalayan regions. Worldwide, geothermal resources make up 7.9% of all resources. Geothermal energy offers a geographical advantage in China when compared to traditional fossil fuels, wind power, and solar power.

Wind and solar power, which do not rely on fossil fuels, make up 50.9% of China's installed capacity. This means that the country has already achieved a goal that was set in 2021, when renewable capacity was supposed to surpass fossil fuel capacity by 2025.

South Africa

Declaring a national disaster will help alleviate the economic and social impacts of the power outage, lessen the impact of load shedding, and allow the government to take practical steps to aid businesses involved in the food supply chain, from production to storage to retail, such as deploying solar panels, generators, and ensuring a constant supply of power. The government moved swiftly to significantly increase the country's ability to generate energy, beyond what Eskom already produces. Permitting private developers to produce power is one of the nation's powerful reforms. There are over a hundred projects underway, with a combined projection of over nine thousand megawatts (MW) of additional capacity. Less strain on the national grid and less likelihood of blackouts are two outcomes of these energy changes. By ensuring energy security and moving at a pace the country can afford, South Africa will continue its just transition to a low carbon economy. Producing electricity from renewable sources would make it more affordable and reliable, which will help South African industry maintain their competitiveness on a worldwide scale. By putting money into electric cars and hydrogen, South Africa will be ready for the clean energy future that the world will face. We can grow our mining sector in strategic minerals that are essential for renewable energy, such as lithium, platinum, vanadium, cobalt, copper, and manganese. South Africa's green hydrogen potential is unparalleled, thanks to the country's cutting-edge technology, local knowledge, and abundant solar and wind power.

At present, seven hydroelectric power facilities dot the landscape of South Africa. With about 500 millimeters of precipitation per year—just 60% of the global average—the country's hydroelectricity potential is severely constrained.

A goal of 10,000 GWh of energy production from renewable sources (mostly wind, solar, biomass, and small-

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scale hydro) has been established in the White Paper on Renewable Energy. There are already a lot of solar water heater manufacturers and installers in South Africa, therefore the market is growing quickly to satisfy demand. As part of its rural water-provision and sanitation initiative, the Department of Water Affairs is making more use of solar electricity to pump water. There has never been a significant wind-turbine facility in sub-Saharan Africa until Eskom's Klipheuwel, located north of Cape Town.

There are no large-scale geothermal resources in South Africa that could be used to produce power or direct heat. Six percent of South Africa's power comes from two nuclear reactors. The most prolific thorium mine on Earth is located in South Africa. Thorium has the potential to be used as a fuel for generating nuclear energy.

Brazil

Brazil has plenty of opportunities to cash in on its climate-relevant mineral reserves, join the solar energy product market, and grow its green hydrogen business. In Brazil, the private sector may be pivotal in helping the economy decarbonize and become more robust. Brazil relied heavily on hydroelectric power for decades to power its electricity needs. The country aims to achieve Net Zero by 2060, with a decrease of 43% from 2005 levels by 2030 as an interim measure (The World Bank, 2023 May 4). This provides it a head start in the journey towards that goal. In March 2022, Brazil reaffirmed its promise to reduce greenhouse gas emissions by 37% by 2025 and by 50% by 2030 compared to 2005 in its most recent Nationally Determined Contribution (NDC). Achieving climate neutrality by 2050 is a long-term target that Brazil has committed to. In contrast to the global average of 15–27%, renewable energy sources account for nearly half of Brazil's energy supply, with more than 80% of its power coming from them. It would not cost Brazil more to increase its use of renewable energy sources than to continue with its present plans to increase its use of fossil fuels. In 2020, hydropower met 66% of Brazil's electricity demand, demonstrating its reliance on hydropower as a power producing source. With rapid expansion in recent years, renewable energy sources including wind and solar accounted for 11% of the nation's electricity in 2020. A total of 8% came from biomass (gov.br, 2020 December 14). Economically exploited low temperature geothermal systems have a combined capacity of 365 MWt, and they consume around 6,540 TJ of energy per year. The majority of this capacity is attributed to around twelve spring systems.

For every major economic sector in Brazil, the McKinsey&Company study found 120 ways to cut greenhouse gas emissions. From 2.8 GtCO2e to 0.9 GtCO2e, that's the projected reduction in greenhouse gas emissions by 2030. The result would be a 70% decrease in greenhouse gas emissions, or the elimination of 1.9 GtCO2e.

Russia

In its base case, a "intensive" scenario, Russia sought to reduce carbon dioxide emissions by 79% by 2050. Power plants that use coal to generate electricity would be replaced with ones that use gas turbines, nuclear power, hydroelectricity, or renewable energy sources, according to the proposal. By diversifying their product offerings to include higher-value items and increasing the competitiveness of Russian hydrocarbons, the plan's adopters hope to stem the falling tide of Russian oil and gas exports. According to the proposal, emissions will reach their highest point in 2030 and then begin to decrease.

With 102 hydropower facilities capable of producing more than 100 MW, Russia ranks fifth globally for hydropower production. Only 20% of its hydro potential has been utilized, despite it being the second most prolific in the world. Siberia and Russia's far east contain the majority of the world's hydro resources, which account for nine percent of the total. Russia has a lot of undeveloped hydroelectric potential that might significantly boost its production; the country already produces over 20% of the world's electricity from these facilities.

Renewable energy resources such as wind, hydro, geothermal, biomass, and solar power are abundant in Russia, complementing the country's abundant oil, gas, and coal reserves. Despite Russia's rich and varied renewable energy resources, fossil fuels still account for the vast majority of the country's energy consumption.

Currently, the majority of geothermal resources are being utilized to heat communities in the North Caucasus and Kamchatka. Residential and commercial structures account for 50% of geothermal heat output, greenhouses for 35%, and industrial processes for 13%. According to Svalova (2003), Russia is home to five large geothermal power facilities.

All throughout Russia, 38 nuclear reactors are cranking out 29.4 GW of power. In addition to the thirty-four reactors that are currently in various phases of planning, four more are currently under construction. Russia possesses a significant amount of uranium, accounting for around 9% of the world's total.

As a long-term climate policy, Russia presented its "Strategy of socio-economic development of the Russian Federation with low greenhouse gas emissions by 2050" to the UNFCCC on September 5, 2022. The strategy was adopted in October 2021. Russia has pledged to eliminate all greenhouse gas (GHG) emissions by the year 2060 as a component of its strategy.

5. Conclusions and Policy Recommendations

The BRICS countries' current and future economic, energy, and environmental situations and tendencies have been the center of attention. When it comes to economic output, energy consumption, and environmental metrics, China and India rank first among the BRICS nations. Here is a correlation coefficient matrix that includes all BRICS countries: population size, GDP, primary energy consumption, and CO_2 equivalent emissions. Carbon trading markets were considered as a potential solution by the BRICS countries to achieve their objective of reducing carbon emissions. There has been an assessment of climate action performance using five metrics, which have been conducted (a) within the BRICS group and (b) between the BRICS group and the G20, the OECD, and the rest of the globe. In every category, India has performed better than any of the other BRICS countries and the globe at large. When looking at the BRICS forum's overall record in climate action, India and Brazil both make strong positive contributions. Aside from Russia, the other BRICS countries have also underperformed relative to their peers and the global average. Overall, the BRICS group has done better than the G20 and the OECD. In order to achieve a low-carbon economy, the BRICS nations have concentrated their efforts, strategies, and initiatives.

For low-carbon economies, renewable energy sources could be the major supply option. Utilizing available renewable energy resources is possible by alterations in all available energy systems. The major challenge faced in the energy sector today is the transition from no sustainable available energy system to renewable energy. Some of policy recommendations may be made as:-

(a) Accelerate the power sector transition by increasing bioenergy resources, hydroelectricity, solar and wind power generation capacity,
(b) Accelerating electrification in private and commercial vehicles and providing adequate charging infrastructure,
(c) Ensuring a just transition for those regions and communities most affected by the shift away from fossil fuels,
(d) Strengthen carbon pricing and cut fossil fuel subsidies,
(e) Remove barriers to investing in the green economy,
(f) Conserve energy and develop energy security,
(g) Promote waste reduction in the community etc.

6. Limitations and Future Research Directions

In general, if a table is too long to fit one page, the table number and heading should be repeated on the next page before the table is continued. Alternatively the table may be spread over two consecutive pages (first an even numbered, then an odd-numbered page) turned by 90, without repeating the heading. Please do not use bold font in tables.

A number of important factors were overlooked in this analysis, including (a) the expenses associated with transitioning from nonrenewable to low-carbon energy sources, (b) the demand-supply gap of renewable energy, (c) the environmental effects of using nonrenewable energy sources, and (d) the imports and exports of renewable energy. Following are some of the future research directions towards low-carbon economy:-

(a) Directing innovation towards a low-carbon future,
(b) Low carbon financing and marketing,
(c) Optimized transition from nonrenewable energy sources to renewable energy sources,
(d) Exploring renewable energy sources,
(e) Removing tariffs and nontariff barriers to trade in clean energy and energy efficiency technologies etc.

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References

[1] P.A. Adedeji, S. Akinlab, N. Madushele and O.O. Olatunji, "Towards low-carbon energy state in South Africa: a survey of energy availability and sustainability," *EAI Endorsed Transactions on Energy Web*, 7(26), 2020, 1-15.
[2] L. Basso and E. Viola, "Are the BRICS Engaged in the Low Carbon Transition?," *CEBRI-Journal*, 1(4), 2022, 123-151.
[3] L. Cai, F.O. Agyeman, L.A. Ayisi and R. Brenya, "Emperical Analysis of BRICS Countries Pathway Towards Low-Carbon Environment," *Research Gate*, 2021, 1-19.
[4] S. Dey, A. Sreenivasulu, G.T.N. Veerendra, V. Rao and P. S. S. A. Babu, "Renewable energy present status and future potentials in India: An overview," *Innovation and Green Development*, 1, 2022, 1- 22.
[5] R. D'Souza, "A Stocktaking of BRICS Performance in Climate Action," *ORF (Observer Research Foundation) Special Report No. 182*, 2022, 1-23.
[6] J. Maryam, A.Mittal and V. Sharma, "CO2 Emissions, Energy Consumption and Economic Growth in BRICS:An Empirical Analysis," *IOSR Journal Of Humanities And Social Science (IOSR-JHSS)*, 22(2), 2022, 53-58.
[7] A. Nayak, K. Paul and K.K. Bagchi, "Demand-Supply Gap in Energy Use in BRICS Countries with Special Reference to India - Emerging Challenges and Policies," *Regional Economic Development Research*, 3(2), 2022, 297-317.
[8] D.H. Nghuyen and I.P. Khominich, "The measurement of green economic quality in the BRICS countries: Should they prioritize financing for environmental protection, economic growth, or social goals?," *Russian Journal of Economics*, 9, 2023, 183–200.
[9] M.K. Sahu, "Energy Revolution under the BRICS Nations," *BRICS Law Journal*, III (1), 2016,34-41.
[10] F. Vieira, S.N.P. Guimar and V. M. Hamza, "Updated Assessment of Geothermal Resources in Brazil," *14th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro*, Brazil, 2015, 1-6.
[11] Y. Wang, Y. Liu, J. Dou, M. Li and M. Zeng, "Geothermal energy in China: Status, challenges, and policy recommendations," *Utilities Policy*, 64(7), 2023.
[12] F. Zhang, R. Zhao, Y. Yang and X. Zou, "Carbon Trading in BRICS Countries: Challenges and Recommendations," *Journal of Economics and Public Finance*, 9(3), 2023, 127-139.
[13] L. Chapungu, G.Nhamo, D. Chikodzi and M A Maoela, "BRICS and the Race to Net-Zero Emissions by 2050: Is COVID-19 a Barrier or an Opportunity?" *Journal of Open Innovation: Technology, Market, and Complexity*, 8(4), 2022, 172.

[14] M.C. Udeagha and N. Ngepah, "Achieving decarbonization goals in BRICS economies: Revisiting the joint role of composite risk index, green innovation, and environmental policy stringency," *Cogent Social Sciences*, 9(1), 2023.

[15] J. Yin, M. Zheng and J. Chen, "The effects of environmental regulation and technical progress on CO2 Kuznets curve: An evidence from China," *Energy Policy*, 77, 2015, 97–108.