

Renewable Energy and Energy Security in BRICS Countries

الطاقة المتجددة والأمن الطاقوي في دول بريكس

Bouzenoura Asma^{1,*}

University of Algiers 3

Received: 2025/06/01; Accepted: 2025/06/28

Abstract: This study examines the impact of renewable energy on energy security in BRICS countries from 2015 - 2024, considering economic, political, and environmental challenges. These nations, rich in natural resources, play a key role in the global energy landscape. Using a descriptive-analytical approach, the study explores how renewable energy contributes to energy security. The findings show that China and India have improved energy security through renewable expansion, while Russia still relies heavily on fossil fuels. The study highlights the need for greater investment in clean energy to enhance sustainability, reduce market risks, and support a more resilient and secure energy future for BRICS countries.

Keywords: BRICS countries, Renewable energy, Energy security

Résumé : Cette étude examine l'impact des énergies renouvelables sur la sécurité énergétique dans les pays des BRICS entre 2015 - 2024, en tenant compte des défis économiques, politiques et environnementaux. Ces nations, riches en ressources naturelles, jouent un rôle clé dans le paysage énergétique mondial. En adoptant une approche descriptive et analytique, l'étude explore la contribution des énergies renouvelables à la sécurité énergétique. Les résultats montrent que la Chine et l'Inde ont renforcé leur sécurité énergétique grâce à l'expansion des énergies renouvelables, tandis que la Russie dépend encore fortement des combustibles fossiles. L'étude souligne l'importance d'investir davantage dans l'énergie propre pour renforcer la durabilité, réduire les risques du marché et assurer un avenir énergétique plus résilient et sécurisé pour les BRICS.

Mots-clés : Pays des BRICS, Énergies renouvelables, Sécurité énergétique .

ملخص: تحلل هذه الدراسة أثر الطاقة المتجددة على أمن الطاقة في دول بريكس خاصة خلال الفترة من 2015 - 2024، في ظل التحديات الاقتصادية والسياسية والبيئية. حيث تلعب هذه الدول، التي تتمتع بموارد طبيعية وفيرة دورا محوريا في مشهد الطاقة العالمي. وباستخدام المنهج الوصفي-التحليلي، تستكشف الدراسة كيفية مساهمة الطاقة المتجددة في تعزيز أمن الطاقة. وتظهر النتائج أن الصين والهند حققنا تقدما ملحوظا من خلال التوسع في مصادر الطاقة المتجددة، بينما لا تزال روسيا تعتمد بشكل كبير على الوقود الأحفوري. وتؤكد الدراسة على ضرورة زيادة الاستثمار في الطاقة النظيفة لتعزيز الاستدامة وتقليل مخاطر السوق، ودعم مستقبل طاقي أكثر أمانا ومرونة لدول بريكس.

* Bouzenoura Asma.

I. Introduction:

Energy is a fundamental driver of economic and social development, as industrial growth and economic stability heavily rely on its availability. With increasing environmental challenges and the volatility of fossil fuel markets, renewable energy has emerged as a strategic option for ensuring sustainable energy security. In this context, BRICS countries (Brazil, Russia, India, China, and South Africa) play a pivotal role in the global energy landscape, possessing abundant natural resources and adopting diverse policies for energy transition.

The period from 2015 to 2024 has witnessed significant transformations in energy policies within BRICS nations. These countries have actively pursued the diversification of their energy sources to reduce dependence on fossil fuels and achieve greater self-sufficiency in energy supply. China, for instance, leads the world in solar and wind energy production, while India is striving to expand its renewable energy capacity as a means of securing its energy stability. Conversely, Russia faces challenges in diversifying its energy mix due to its heavy reliance on oil and gas, whereas Brazil and South Africa seek to leverage their natural resources to enhance energy sustainability.

Against this backdrop, the central research question of this study is: To what extent does renewable energy impact energy security in BRICS countries, particularly in light of the economic, political, and environmental challenges they face? Have these countries successfully achieved energy security by adopting renewable energy sources? What are the key factors that have contributed to or hindered this transition?

We rely on the following hypotheses as answers to the previously stated questions:

The adoption of renewable energy sources significantly contributes to enhancing the energy security of BRICS countries by reducing dependence on fossil fuels and diversifying energy supply sources. China and India have made remarkable progress in securing their energy needs through the expansion of renewable energy sources, whereas Russia faces challenges due

This study aims to analyze the relationship between renewable energy and energy security in BRICS countries during the period 2015–2024 by examining the strategies implemented, existing challenges, and future opportunities for enhancing energy sustainability. Additionally, it will highlight the differences among the five nations in their adoption of renewable energy technologies and the resulting implications for their energy stability, ultimately contributing to a deeper understanding of BRICS' role in shaping the future of global energy.

I.1. Definition of Renewable Energy in BRICS Countries:

Renewable energy in BRICS countries refers to energy derived from naturally replenishing sources such as solar, wind, hydro, biomass, and geothermal power. These countries Brazil, Russia, India, China, and South Africa have collectively invested in renewable energy to enhance energy security, reduce carbon emissions, and promote sustainable development. Given their economic and

industrial growth, BRICS nations play a crucial role in the global renewable energy transition, contributing significantly to installed renewable capacity and technological advancements (REN21. *Renewables Global Status Report 2023*)

I. 2. Definition of Energy Security:

Energy security refers to the uninterrupted availability of energy sources at an affordable price. It encompasses aspects such as reliable energy supply, diversified energy sources, infrastructure resilience, and the ability to withstand supply shocks. In the context of global sustainability, energy security also includes the transition to renewable and low-carbon energy sources to reduce dependence on fossil fuels and mitigate environmental risks. Ensuring energy security is crucial for economic stability, national security, and sustainable development. In the case of BRICS countries (Brazil, Russia, India, China, and South Africa), the diversity of energy resources and the varying levels of reliance on fossil fuels versus renewable energy make the energy security analysis of each country unique (International Energy Agency (IEA). 2023)

II– Methods and Materials:

The study employs a descriptive approach to illustrate the state of renewable energy in BRICS countries and track the evolution of their energy policies over the studied period. A quantitative and analytical approach will be used to assess the relationship between renewable energy and energy security levels in each country, identifying the changes in energy strategies. Furthermore, a comparative approach will be applied to evaluate the varying experiences of BRICS nations in their reliance on renewable energy and its impact on their energy security.

III- Results and discussion :

III. 1 - Analysis of Renewable Energy Indicators in BRICS:

We rely on four highly significant indicators in the five BRICS countries: hydropower, solar energy, wind energy, and solid biofuels and renewable waste. We measure these indicators in each of the five BRICS countries individually, considering the unique characteristics of each country over the last ten years from 2015 to 2024.

III. 1.1- Renewable Energy Indicators in Brazil

Brazil is uniquely positioned among BRICS countries, as it has one of the world's cleanest energy matrices and a great potential for renewable sources at competitive costs. The country has a significant hydroelectric installed capacity, with large reservoirs and a nationally interconnected electrical system, which can facilitate the integration of wind, solar and biomass energy. Brazil also has a mature biofuel industry, with several alternatives to oil by-products, especially in the transportation sector. (Luciano Losekann , and Amanda Tavares, May 2021,p:74)

Based on the data from the International Energy Agency for the period 2015–2023, the following figure was obtained Figure (1)

The figure (1) shows the almost complete dominance of hydroelectric power in the renewable energy mix throughout the study period, with its total contribution to the renewable energy mix reaching 63% in 2022. This is due to the abundance of water resources in Brazil and its terrain, which facilitates the construction of dams and, consequently, hydroelectric power plants. This has made Brazil the second-largest producer of hydroelectric power in the world, with hydroelectric power contributing approximately 80% to electricity generation.(<https://www.iea.org/countries/brazil>)

As we observe the increasing interest in wind energy production, Brazil has significantly expanded its wind power generation capacity, particularly in recent years. In fact, wind energy has come to account for approximately 10-12% of Brazil's total electricity generation as of 2023.(<https://www.mordorintelligence.com/ar/industry-reports/brazil-wind-energy-market>)

The figure shows the rapid growth of solar energy in Brazil starting from 2017 due to the inauguration of three major solar farms in the same year, which are among the largest in the world. The total capacity of these three stations reached 704 megawatts, which is more than ten times the total installed capacity in the country compared to 2015.(<https://www.pv-tech.org/brazil-expected-to-hit-1gw-of-solar-this-year/>) The capacity increased even more in recent years, especially starting from 2021, Brazil ranked 14th globally in terms of cumulative solar PV capacity. However, it comfortably broke the top 10 in terms of added solar PV capacity, securing fourth place with 5,176 MW (<https://www.pv-tech.org/brazil-expected-to-hit-1gw-of-solar-this-year/>)

Brazil is a global leader in the production and use of biofuels, especially ethanol derived from sugarcane. The country has a well-established ethanol industry and is the second-largest producer of ethanol in the world(<https://www.pv-tech.org/brazil-expected-to-hit-1gw-of-solar-this-year/>)

Brazil's renewable energy mix is predominantly focused on hydropower, with increasing efforts directed towards solar, wind, and bioenergy. These sectors have been established as strategic priorities, positioning the country among the global leaders in renewable energy. This underscores Brazil's commitment to implementing measures aimed at maintaining environmental balance

II.1.2-Renewable energy indicators in China

China is the world's largest consumer of primary energy and is responsible for 30 %of the global CO₂emissions twice those of the US and three times those of the EU. Coal composes the base of China's energy system, despite a drop in its relative participation from 70 to 58 %over the last decade, Despite this, China is working to mitigate the negative environmental impacts resulting from its heavy reliance on fossil fuels. This is achieved by increasingly incorporating renewable energy sources into its overall energy consumption.(Luciano Losekann , and Amanda Tavares, May 2021,p:86)

Based on the data of renewable energy consumption in China, we have derived the following insights Figure (2)

The figure clearly shows the significant attention China pays to solar energy production. Over nine years, the increase in its production has been equivalent to 13 times the amount in 2015, with a high average increase of approximately 244,024.7 during the period 2015-2023. China's

solar capacity represents more than one-third of the global capacity, possessing the largest installed solar power capacity in the world. This sector is strongly supported by government policies and substantial investments. The figure also shows a significant rise in wind energy production, with a 237% increase in 2023. China ranks first globally in the installation of wind turbines, both onshore and offshore, and the government strongly encourages the development of this sector through ambitious plans and the provision of necessary infrastructure(<https://gwec.net/globalwindreport2023>).

Furthermore, the figure highlights the high contribution of hydropower production, as China relies on the development of large hydropower projects due to the availability of water resources and suitable terrain, especially dams like the Three Gorges Dam, which is one of the largest hydropower projects in the world. Consequently, hydropower has become the largest source of renewable energy in China and the second-largest energy source overall, after coal . According to the International Hydropower Association, China is the world's largest producer of hydropower as of 2021. China's installed hydropower capacity in 2021 was 390.9 GW, including 36.4 GW of stored hydropower capacity(2021 Hydropower Status Report)

China spent 13 US\$ billion in renewable energy in 2020 and is one of the world's largest green bond issuers. China is developing cutting-edge technologies that support the deployment of clean energy sources and energy efficiency, such as highly efficient smart power systems and batteries, carbon capture and storage, electric vehicles and hydrogen use in the transportation sector, as well as alternative methods for producing carbon-free hydrogen. China also dominates the global supply chain for solar photovoltaic panels and ultra-fast charging battery cells(Luciano Losekann , and Amanda Tavares,P:89)

These positive indicators suggest that China has a significant contribution to the global shift towards renewable energy, particularly within the BRICS countries. This will greatly enhance air quality and reduce carbon emissions, thereby contributing to global efforts to combat climate change.

III.1.3- Indicators of Renewable Energy in India

India is ranked fourth globally in installed renewable energy capacity, fourth in wind energy capacity, and fifth in solar energy capacity this is according to the statistics of the International Energy Agency for the year 2023.

India's potential in renewable energy can be further illustrated through the following figure, which shows its development from 2015 -2023.Figure (3)

We observe from the figure(3) the increasing interest in renewable energy sources during the period 2015-2023, with a greater focus on solar energy due to India's long hours of sunshine, vast area, and favorable climatic conditions. The increase over nine years reached 1183.2%, meaning that the interest in solar energy production in 2023 was about 12 times higher compared to 2015. This is due to India having the lowest cost globally for setting up solar power plants.(Sudheer Singh, , May 30, 2019)

Following solar energy is wind energy, which increased by 78.3% over nine years. We also note that during this period, the interest in hydropower production was limited, with a growth rate of 10%, while there was increasing interest in converting solid biofuels and renewable waste.

The country aims to increase its consumption of natural gas, which is currently low, as part of the national plan to reduce air pollution, especially in urban areas. The government provides incentives for private and public companies to produce natural gas, especially unconventional gas and gas found in deep waters, and plans to expand the infrastructure of gas pipelines, regasification plants, and distribution stations for compressed and bio natural gas. (Luciano Losekann, and Amanda Tavares, P16)

We conclude that India has two significant renewable energy sources: solar energy in the first place and wind energy in the second place. India's focus on solar and wind energy aligns with its vast potential in these areas, driven by favorable climatic conditions and technological advancements. The government's supportive policies and international collaborations have played a crucial role in this growth

III.1.4- Indicators of Renewable Energy in Russian

Russia ranks fourth in the world for primary energy consumption and carbon dioxide emissions and maintains its focus on fossil fuels despite enormous renewables potential. Russia is following a “business as usual” strategy, But the changing global environment, Sustainable Development Goals agreed upon in the UN institutions in 2015 and the decarbonization agenda, as well as the wellbeing of the whole economic system in the country, challenge this energy mix (Hafner Giacomo Luciani, 2022, P50)

its consumption of renewable energy can be illustrated by the figure(4) for the period 2015-2023.

As seen in Figure 4, hydropower constitutes the majority of the Renewable resource capacity. According to the International Renewable Energy Agency (IRENA), hydropower contributed 63% to global electricity generation during the period 2020-2022. Russia stands as a leading nation in hydropower, holding the second position globally. Hydropower accounts for approximately 19% of Russia's overall electricity production (Bogoviz, Aleksei V.; Lobova, Svetlana V.; Alekseev, Alexander N, 2020, p:484)

Hydro energy is followed by bioenergy, solar energy and wind energy. While wind energy capacity has expanded dramatically since 2018, solar energy capacity has increased since 2016. Wind energy was initially used in 2000, In 2011, solar energy was used for the first time, with a solar energy capacity of less than 0.01 TW. By 2020, the energy obtained from the sun increased to 1.67 TW (Nurcan Kilinc-Ata, Ilya A. Dolmatov, February 2023,p2)

Federation's aim of a 2.5% share of wind and solar energy in electricity generation by 2020 has not been realized, and the current ratio is 0.3%. The Russian Federation plans to reach 12 GW of Renewable capacity by 2035, and to do so, Russian authorities stated in June 2021 that they would

grant state support to RE projects worth 360bn RUB through 2035(Nurcan Kilinc-Ata, Ilya A. Dolmatov, February 2023,p4)

Russia possesses significant traditional energy resources such as gas, oil, and coal, which makes it challenging to develop renewable energy sources at the same pace as other BRICS countries like India and Brazil. Nuclear and hydropower account for a substantial portion of Russia's energy needs, which may explain the limited focus on renewable energy projects such as wind and solar power.

Additionally, the harsh climate in many parts of Russia makes it difficult to effectively establish and operate solar energy projects. However, there are ongoing efforts to improve this situation, and there may be changes in the future with increasing interest in renewable energy and new technologies.

III. 1.5- Renewable Energy Indicators in SOUTH AFRICA

As the seventh coal producer in the world, around 77% of South Africa's electricity is generated from coal resulting in a high level of environmental degradation. South Africa's per capita greenhouse emissions are the highest in Africa. Besides, centrally generated power is not able to reach the remote areas because of the lack of distribution infrastructure. South Africa has a large potential for both, solar and wind power generation, with smaller potential for biomass, landfill gas and hydropower(Shilpi Jaina , Pushpendra K. Jain, issue 143, p:721)

The figure (5) presents the key indicators of renewable energy in South Africa

The chart reveals that South Africa's renewable energy mix heavily prioritizes solar power. This trend is supported by ongoing data from the International Energy Agency (IEA), which highlights solar energy's cost-effectiveness relative to other renewable resources. This is further reinforced by the country's geographical location, which receives significant levels of solar irradiance. In 2023, 79% of all new capacity installed in the past year was installed in South Africa (almost 3GWp out of a total 3.75GWp). In fact, South Africa saw the biggest increase in solar installations in African history for two consecutive years 2022 and 2024 (<https://techcentral.co.za/the-astonishing-scale-of-solar/238529>)

Following solar energy, hydropower and wind power emerge as significant components of the renewable energy mix. The chart highlights a notable increase in wind energy production, with a 219% surge in 2023 compared to 2015, indicating growing interest in this renewable source. Over 80% of South Africa's land area has wind resources to support development of economic wind farms with annual load factors greater than 30% and total wind power potential of 6,7000 GW, which is competitive with solar potential. South Africa requires 250 TWh/y energy which could all be generated from wind farms of a combined capacity of 75GW over 0.6% of the country's land area(Shilpi Jaina , Pushpendra K. Jain, p:724)

South Africa has significant potential for solar and wind energy due to its climate and terrain. challenges related to infrastructure and policies may limit the full realization of this potential compared to other BRICS countries like China and India.

III.2 - Analysis of Renewable Energy Indicators in BRICS:

Energy security is a fundamental pillar of economic and developmental stability, particularly for BRICS countries, which play an increasingly significant role in global energy markets. Energy security reflects a nation's ability to secure sustainable and affordable energy supplies while minimizing dependence on traditional sources that may be vulnerable to geopolitical or economic fluctuations. The level of energy security among BRICS countries varies according to their energy mix, diversification strategies, investment levels in renewable energy, and energy policies.

Based on the previous analysis, a comparative assessment of the five BRICS countries in the field of renewable energy can be conducted by highlighting the strengths and challenges of each nation.

III.2.1- Brazil – A Model of Sustainable Energy Security:

Strengths:

Brazil has one of the world's cleanest energy matrices, with 63% of its electricity generated from hydropower(Luciano Losekann & Amanda Tavares, 2021, p:2.)

- The country possesses vast potential for wind and solar energy and a well-developed biofuel industry, reducing its reliance on oil.
- Its integrated energy infrastructure supports energy security.

Challenges:

- High vulnerability to climate change risks (e.g., droughts affecting hydropower generation).
- The need for further diversification to avoid overreliance on hydrology.

Brazil enjoys a high level of energy security due to its renewable energy diversification, but it must mitigate climate-related risks affecting hydropower production.

III. 2.2- China – Between Economic Growth and Environmental Challenges:

Strengths:

- China has the world's largest installed capacity for solar and wind energy and is a global leader in battery and energy storage technologies, enhancing its energy independence.
- The country invests heavily in hydrogen and nuclear energy as part of its long-term strategy.
- Government policies and financial incentives have positioned China as a global leader in clean energy technologies.

Challenges:

- Still relies on coal for 58% of its energy needs, posing environmental concerns and energy security risks in light of global carbon reduction policies(Global Wind Energy Council, "Global Wind Report 2023)
- Requires further development of smart grid infrastructure to efficiently integrate renewable energy sources.

Despite its massive investments in renewable energy, China's energy security remains challenged by its high dependence on coal and global market fluctuations.

III.2.3-India – Rapid Expansion Amid Structural Challenges

Strengths:

- India ranks fourth globally in renewable energy capacity, with a remarkable 1183.2% growth in solar energy between 2015 and 2023(International Energy Agency, "India Energy Outlook 2023)
- One of the lowest solar energy production costs worldwide, enhancing its energy security.
- Supportive government policies, such as the "India 2047 Sustainable Energy Plan," aim to reduce coal dependence.

Challenges:

- Weak power transmission and distribution infrastructure, leading to significant energy losses.
- Continued reliance on coal and natural gas, exposing the country to economic and price volatility.

India is making significant progress toward sustainable energy security, but weak infrastructure remains a critical barrier that must be addressed.

III. 2.4- Russia – An Energy Powerhouse with Fossil Fuel Dependence Risks

Strengths:

- Russia holds the world's second-largest natural gas reserves, ensuring strong short- and medium-term energy security.
- It is a leading producer of hydropower, which accounts for 19% of its electricity generation(Hafner & Giacomo Luciani, Springer, 2022)" "

Challenges:

- Minimal investment in renewables, with wind and solar energy accounting for only 0.3% of total electricity production.

- Economic sanctions have hindered new energy projects, particularly those requiring Western technologies.
- Heavy reliance on energy exports creates geopolitical vulnerabilities (e.g., the Ukraine conflict's impact on Russian energy security).

Despite its vast resources, Russia's energy security is undermined by a lack of diversification and its heavy dependence on energy exports.

III. 2.5-South Africa – Coal Dependence with Untapped Renewable Potential

Strengths:

- South Africa has immense potential for solar and wind energy and is experiencing rapid growth in these sectors.
- Its geographical location provides some of the highest solar radiation levels, making solar energy a highly viable option.

Challenges:

- 77% of electricity is generated from coal, making South Africa the highest carbon emitter in Africa (Shilpi Jain & Pushpendra K. Jain, 2019)
- Weak electricity infrastructure results in frequent power outages.
- Requires substantial investments in renewable energy and improved grid management.

While South Africa has significant potential for energy security through renewables, structural and policy-related obstacles hinder its progress.

III.3 - Comparison of Energy Security in BRICS Countries

The table(1) provides a comparative analysis of BRICS countries based on key energy security indicators, including energy availability, affordability, efficiency and sustainability, accessibility...

The comparative analysis of energy security among BRICS countries confirms the following:

- Brazil enjoys the highest level of energy security among BRICS nations due to its heavy reliance on hydropower and growing renewable energy sector.
- China, despite its ongoing dependence on coal, leads globally in renewable energy investment and storage solutions, ensuring long-term stability.
- India is making rapid progress in renewables, but weak infrastructure poses a major challenge to its energy security.
- Russia has vast fossil fuel reserves but lags behind in renewables, making it susceptible to market volatility and geopolitical risks.
- South Africa faces the greatest energy security challenges due to its extreme reliance on coal, frequent blackouts, and the urgent need for renewable energy investments.

IV- Conclusion:

The findings suggest that while renewable energy has played a significant role in enhancing energy security in some BRICS nations, its effectiveness varies due to structural and policy-related factors.

China and India have made significant strides in integrating renewable energy into their national grids, largely due to strong government support, technological advancements, and large-scale investments. These efforts have improved their energy diversification and reduced dependence on fossil fuels, strengthening their overall energy security.

On the other hand, Brazil, despite its reliance on hydropower, remains exposed to climate-related vulnerabilities such as droughts. Similarly, Russia continues to prioritize fossil fuels and nuclear energy, limiting its transition to renewables and, consequently, its ability to achieve long-term energy security through sustainable means. South Africa faces a different set of challenges, including infrastructure limitations and regulatory constraints, which have hindered the full deployment of its renewable energy potential.

The success or stagnation of the renewable energy transition in BRICS countries can be attributed to several key factors:

1. Policy and Governance – Effective regulatory frameworks and government incentives have accelerated the transition in China and India, while weaker policies have slowed progress in Russia and South Africa.
2. Investment and Technological Innovation – High levels of investment and advancements in energy storage and grid integration have facilitated the large-scale adoption of renewables.
3. Environmental and Geographic Constraints – Natural resource availability, such as sunlight, wind, and hydropower potential, has shaped each country's renewable energy strategy and level of success.
4. Economic Stability and Affordability – The financial capacity to support renewable energy projects, including subsidies and infrastructure investments, has been a decisive factor in determining the pace of adoption.

Recommendations

Based on the previous analysis of energy security in BRICS countries and the role of renewable energy in achieving it, the following recommendations can be proposed:

1. **Strengthening Policies Supporting Renewable Energy**
 - BRICS countries should develop more stable and transparent policies to support renewable energy, including financial incentives, tax reductions, and fair pricing mechanisms.

- There is a need to establish long-term national strategies that integrate renewable energy into broader economic and environmental development plans.

2. Increasing Investment in Renewable Energy Infrastructure

- Greater public and private investments should be directed towards solar, wind, hydropower, and energy storage technologies.
- Enhancing transmission and distribution networks to ensure they are more efficient and sustainable in accommodating renewable energy.

3. Enhancing Cooperation Among BRICS Countries in the Energy Sector

- Facilitating knowledge and expertise exchange among member states, particularly between China and India, which have made significant progress, and Russia and South Africa, which face challenges in energy transition.
- Establishing joint investment funds to support sustainable energy projects across BRICS nations.

4. Focusing on Innovation and Technology

- Encouraging research and development in energy storage, efficiency, and smart grids, which can improve the reliability of renewable energy sources.
- Supporting startups and technological ventures that focus on sustainable energy solutions.

5. Reforming Regulatory Frameworks and Governance

- Improving legislation to eliminate bureaucratic obstacles that hinder the implementation of renewable energy projects.
- Strengthening public-private partnerships to ensure the effective execution of energy projects.

V- Appendices:

Table (1)

Comparison of BRICS Countries in Achieving Energy Security

Indicator	Brazil BR	Russia RU	India IN	China CN	South Africa ZA
Dependence on Fossil Fuels	↓ 35% (Low)	↑ 85% (High)	↑ 70% (High)	↑ 58% (Medium)	↑ 88% (Very High)
Renewable Energy Share	63% (Mainly Hydro)	0.3% (Very Low)	42% (Rapid Growth)	45% (Global Leader)	12% (Low)
Solar and Wind Energy	Growing but behind	Very weak	Very rapid growth	World's largest	High potential but underutilized
Oil & Gas Reserves	Very limited	Very large (2nd largest natural gas reserves)	Moderate	Large but dependent on imports	Limited
Electric Grid Challenges	Climate variability affecting hydroelectric power	Sanctions affecting energy expansion	Weak infrastructure causing inefficiencies	Strong infrastructure but needs upgrading	Major transmission and distribution issues
Environmental Challenges	Relatively low	High due to fossil fuel reliance	Moderate with increasing clean energy	Severe pollution from coal	Very high due to coal
Energy Costs	Low and stable	Stable domestically but export-dependent	Low solar energy costs	Low due to renewable investments	High and unstable
Domestic Energy Supply Security	Stable due to diversification	Stable but export-dependent	Vulnerable to market fluctuations	Stable but needs more storage	Unstable due to frequent power outages
Policies & Investments	Strong support for clean energy	Weak investment in renewables	Highly ambitious (targeting 500 GW renewables)	Largest global investor in clean energy	Unstable policies requiring improvement
Reliance on	Very low	Very low	Moderate	High (imports)	Partially

Indicator	Brazil BR	Russia RU	India IN	China CN	South Africa ZA
Imports	(almost self-sufficient)	(major exporter)	(still imports coal and gas)	oil & gas despite renewable investments)	dependent on imported gas and oil
Future Outlook	Expanding solar and wind energy	Maintaining fossil fuels with limited nuclear investment	Massive renewable expansion	Global leader in clean energy and battery technology	Urgent need to reduce coal dependence

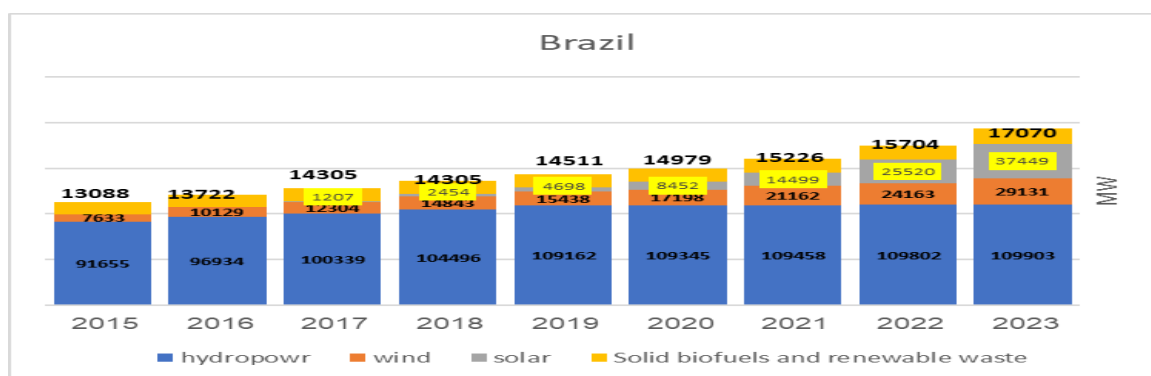
Source : created by the author based on:

- International Energy Agency (IEA) Reports (2015–2023)
- <https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-df61467e070/WorldEnergyOutlook2023.pdf>
- https://www.ren21.net/reports/global-status-report/BRICS_Energy_Cooperation_Roadmap_2025
- United Nations Framework Convention on Climate Change (UNFCCC) Data

https://di.unfccc.int/comparison_by_category

Figure (1)

Indicators of Renewable Energy in Brazil from (2015 – 2023)

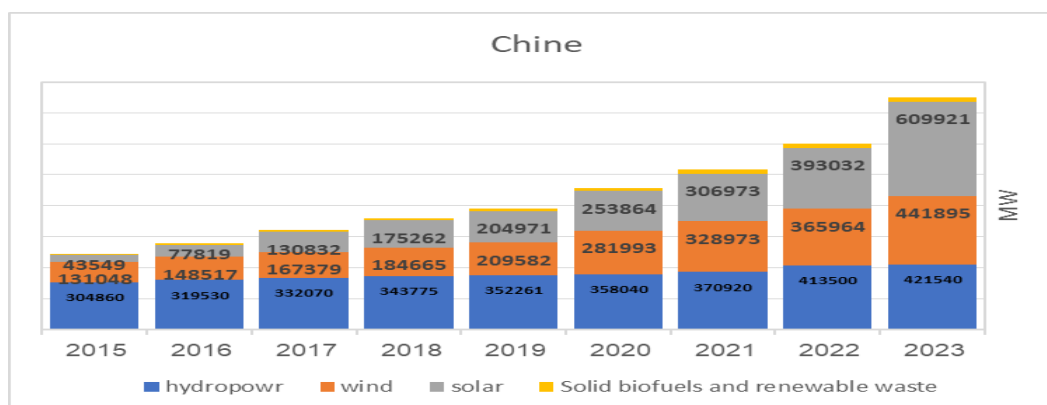


Source: created by the author based on:

https://www.irena.org/media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf?rev=a587503ac9a2435c8d13e40081d2ec34

Figure (2)

Indicators of Renewable Energy in China from (2015 – 2023)

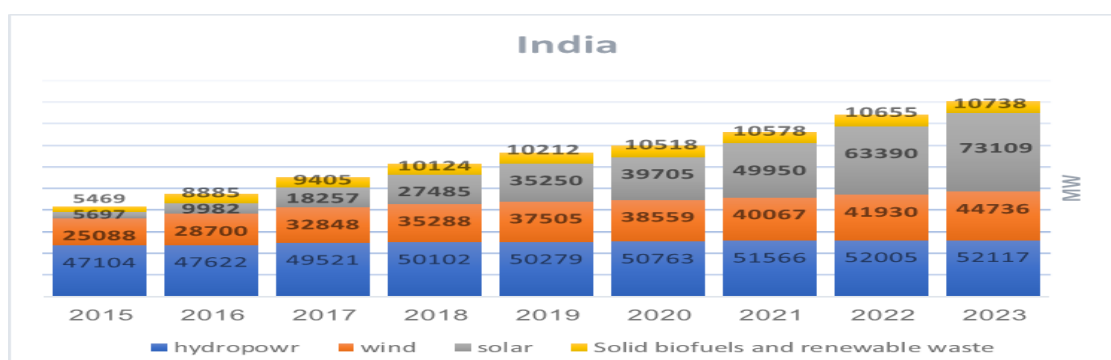


Source: created by the author based on:

https://www.irena.org/media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf?rev=a587503ac9a2435c8d13e40081d2ec34

Figure (3)

Indicators of Renewable Energy in India from (2015 – 2023)

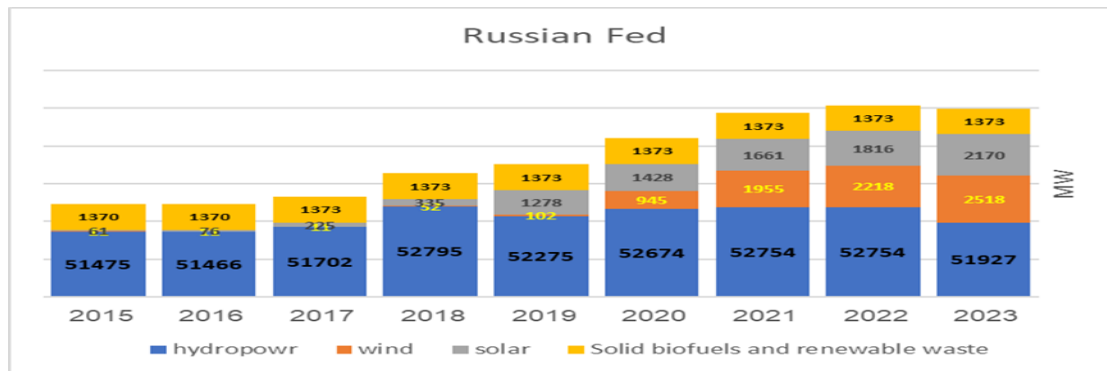


Source: created by the author based on:

https://www.irena.org//media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf?rev=a587503ac9a2435c8d13e40081d2ec34

Figure (4)

Indicators of Renewable Energy in Russia from (2015 – 2023)

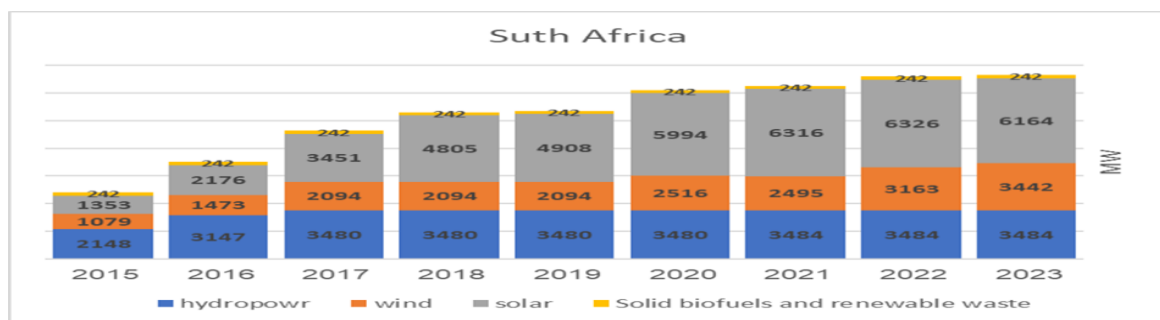


Source: created by the author based on:

https://www.irena.org/media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf?rev=a587503ac9a2435c8d13e40081d2ec34

Figure(5)

Indicators of Renewable Energy in Suth Africa from (2015 – 2023)



Source: created by the author based on :

https://www.irena.org//media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf?rev=a587503ac9a2435c8d13e40081d2ec34

VI. Bibliography:

1. Sudheer S,(2019) "India becomes lowest-cost producer of solar power", **ETEnergyWorld** ,30 May, P89
2. Hafner Giacomo L,(2022)The Palgrave Handbook of International Energy Economics, palgrave macmillan,Springer Nature , P50
3. Bogoviz, Aleksei V.; Lobova, Svetlana V.; Alekseev, Alexander N (2020), Current state and future prospects of hydro energy in Russia, **International Journal of Energy Economics and Policy**, Vol 10 , Issue 3, P159
4. Nurcan Kilinc-Ata, Ilya A. Dolmatov, (2023) The Russian Federation's Renewable Energy Development Determinants: Evidence from Empirical Research, **nternational Journal of Energy Sector Management**, February , vol 17 , issue4, p67

5. Luciano L , Amanda T ,(2021), Potential for cooperation in the dissemination of renewable energy and natural gas among BRICS countries, Policy Research Brief. May,p:4
6. Shilpi J , Pushpendra K. Jain,(2019) The rise of Renewable Energy implementation in South Africa, Energy Procedia , issue 143, p94
7. Hafner & Giacomo Luciani,(2022) "The Palgrave Handbook of International Energy Economics", Springer
8. International Energy Agency (IEA) (2023). *Energy Security: Ensuring the Uninterrupted Availability of Energy*.
9. Luciano & Amanda T, (2023) "Potential for Cooperation in the Dissemination of Renewable Energy and Natural Gas Among BRICS Countries", "Global Wind Report"
10. REN21. Renewables Global Status Report 2023. www.ren21.net
- 11.https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Mar/IRENA_RE_Capacity_Statistics_2024.pdf?rev=a587503ac9a2435c8d13e40081d2ec34
12. <https://www.iea.org/countries/brazil>
- 13<https://www.mordorintelligence.com/ar/industry-reports/brazil-wind-energy-market>
- 14 <https://www.pv-tech.org/brazil-expected-to-hit-1-gw-of-solar-this-year/>
- 15<https://www.solarfeeds.com/mag/2021-solar-statistics-in-brazil>
- 16<https://iea.blob.core.windows.net/assets/338e96c1-7da1-4894-b81b-57ff7bf13040/BiofuelPolicyinBrazil%2CIndiaandtheUnitedStates.pdf>
- 17<https://gwec.net/globalwindreport2023>
18. 2021 Hydropower Status Report
- 19<https://techcentral.co.za/the-astonishing-scale-of-solar/238529>
- 20International Energy Agency, "India Energy Outlook 2023"
- 21<https://iea.blob.core.windows.net/assets/86ede39e-4436-42d7-ba2a-edf61467e070/WorldEnergyOutlook2023.pdf>
- 22[https://www.ren21.net/reports/global-status-report/BRICS Energy Cooperation Roadmap 2025](https://www.ren21.net/reports/global-status-report/BRICS_Energy_Cooperation_Roadmap_2025)
- 23United Nations Framework Convention on Climate Change (UNFCCC) Data
https://di.unfccc.int/comparison_by_category