

Review: Renewable Energy In India: Current Status And Future Potential

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Abstract - In an era defined by growing environmental concerns and the need for sustainable energy sources, the shift towards renewable energy has become a global imperative. This paper delves into the critical role of renewable energy in the context of the Gulf Cooperation Council (GCC) nations, comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). We explore the barriers, risks, and opportunities associated with the adoption of renewable energy technologies in this region, shedding light on the pivotal changes unfolding in the GCC's energy landscape.

Keywords— future, international cooperation, solutions, improvement.

1. Introduction to Renewable Energy

The world is at a critical juncture, with fossil-based oil, coal, and gas reserves dwindling. According to predictions from the World Energy Forum, these finite resources will be depleted within the next century. Fossil fuels currently dominate the energy landscape, constituting over 79% of global primary energy consumption. A significant portion, approximately 57.7%, is used in the transportation sector. The rapid depletion of these resources underscores the urgent need to transition to alternative and sustainable energy sources.

2. The Crucial Role of Renewable Energy

Renewable energy sources have emerged as the linchpin of a sustainable future. These sources derive from natural processes that are constantly replenished and do not deplete over time. Harnessing renewable energy offers numerous advantages, including a substantial reduction in carbon emissions,

improvement of air quality, and the promotion of sustainable development. Notable renewable energy sources encompass traditional biomass, large hydropower, and "new" renewables such as small hydro, modern biomass, wind, solar, geothermal, and biofuels.

3. Global Trends in Renewable Energy Adoption

As of the data available up to 2008, renewable energy accounted for 18% of the world's final energy consumption. Traditional biomass, used predominantly for cooking and heating in developing countries, constituted about 13% of this share and showed signs of gradual efficiency improvements. Large hydropower represented 3% of global renewable energy capacity, with substantial growth occurring in developing nations. "New renewables" made up 2.4% of the share and exhibited rapid expansion in developed and emerging economies.

4. Growth Trajectory of Renewable Energy

The period from 2002 to 2006 witnessed remarkable growth rates for various renewable energy technologies. Wind power, solar hot water, geothermal heating, and off-grid solar PV systems experienced annual growth rates ranging from 15% to 30%. In 2008, the global renewable energy market demonstrated robust expansion, with wind power leading the way as the largest addition to renewable energy capacity. The year saw an estimated \$120 billion in investments in renewable energy worldwide.

5. Environmental and Economic Benefits of Renewable Energy

The shift toward renewable energy sources that utilize indigenous and replenishing resources offers the potential for energy generation with minimal emissions of air pollutants and greenhouse gases. These sources tap into natural phenomena and resources to generate marketable energy, holding immense promise as alternatives to conventional, non-renewable energy sources.

6. Renewable Energy in India: A Growing Imperative

India, with its rapidly expanding population of over 1.028 billion, is facing an increasing annual growth rate of 1.58%. As the availability of fossil fuel energy declines, India grapples with energy shortages, rising energy prices, and energy insecurity. The nation's economic growth, currently valued at approximately \$1 trillion (2008 GDP), ranks among the fastest in the world. However, this growth relies heavily on coal, foreign oil, and petroleum, which are both non-renewable and environmentally detrimental.

7. Projected Energy Demand in India

The Expert Committee on Integrated Energy Policy has projected that by 2032, India's primary commercial energy requirements will soar to four to five times the current levels. Electricity generation capacity will need to increase by 5.6 to 7 times, and oil requirements will rise by a factor of 3 to 6. Meeting these energy demands is pivotal for economic development across all sectors of the Indian economy.

8. India's Renewable Energy Potential

India boasts vast renewable energy potential, and it is committed to becoming a global leader in clean energy production. The government has set ambitious targets for renewable energy, with an estimated potential of around 85,000 MW from commercially exploitable sources. This includes wind power (45,000 MW), small hydropower (15,000 MW), and biomass/bioenergy (25,000 MW). Furthermore, solar

photovoltaic and solar thermal energy have the potential to generate 35 MW per square kilometer.

9. Current Status of Renewable Energy in India

India has made significant strides in renewable energy deployment. Renewable energy, excluding large hydropower, already accounts for 9% of the total installed energy capacity, equivalent to 12,610 MW. When large hydropower is factored in, renewables make up over 34% of the total installed capacity. Windpower alone has reached an installed capacity of over 8757 MW, positioning India as the fifth-largest wind power producer globally.

10. Key Achievements in India's Renewable Energy Sector

India's renewable energy sector has achieved remarkable milestones. Some notable achievements include:

- Wind Power: An installed capacity of over 8757 MW, ranking India as the fifth-largest wind power producer globally.
- Biomass: A potential of 16,881 MW (from agro-residues and plantations) with annual employment opportunities exceeding 10 million man-days in rural areas.
- Small Hydropower: Over 1705 MW installed capacity, with an additional 479 MW under implementation.
- Solar Energy: A solar water heating potential of 140 million m² of collector area.
- Biogas: More than 3.7 million biogas plants installed by December 2004.

11. Government Initiatives and Policies to Promote Renewable Energy

The Government of India has introduced a range of policies and initiatives to encourage the adoption of renewable energy technologies. These measures encompass incentives, subsidies, and regulatory frameworks designed to incentivize the transition to

renewable energy sources. Notably, the National Action Plan on Climate Change (NAPCC) emphasizes the National Solar Mission and aims to significantly increase the share of renewable energy in the national energy mix.

Sustainable Energy Consumption and Economic Growth in BRICS Nations: A Comprehensive Analysis

Introduction:

Economic growth stands as a cornerstone for advancing civilization, underpinned by policies geared towards fostering development, innovation, and international trade. This paper presents an in-depth exploration of the intricate relationship between energy consumption and economic growth, with a specific focus on both non-renewable and renewable energy sources in the BRICS nations: Brazil, Russia, India, China, and South Africa.

Energy Sources and Economic Progress:

To understand the dynamics of economic development, it is pivotal to grasp the significance of energy consumption. Non-renewable energy resources, including coal, petroleum, and natural gas, have traditionally been the catalysts of industrialization due to their efficiency and widespread availability. In contrast, renewable energy sources, such as solar, wind, and hydroelectric power, offer the promise of sustainable growth but often require substantial initial investments.

The Nexus between Energy Consumption and Economic Growth:

The intricate relationship between energy consumption and economic growth has been a subject of extensive research. While some studies postulate a direct and positive correlation, suggesting that increased energy consumption drives economic growth, others emphasize the impact of technological advancements, shifts in energy source composition, and alterations in output composition.

BRICS Nations: Economic Powerhouses in Transition:

The BRICS nations, characterized by robust economic growth, are poised to wield substantial influence in the global economy. As these countries transition towards industrialization, their energy demands soar, necessitating a strategic approach to meet the needs of various sectors, including industry, transportation, and commerce. This surge in energy consumption is emblematic of the ongoing industrial revolution in these nations.

Review of Existing Literature:

Energy's Role in Production: Traditional growth models often overlook energy as a fundamental factor of production. Nevertheless, ecological economists underscore the pivotal role of energy availability in driving production and economic growth.

Economic Growth Models Revisited: Neoclassical models, exemplified by the Solow growth model, tend to marginalize the role of energy and natural resources. Conversely, endogenous growth models acknowledge the significance of technological change and resource management in achieving sustainable growth.

Exploring Hypotheses on Energy-Growth Dynamics: Various hypotheses, including the growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis, illuminate the intricate interplay between energy consumption and economic growth. These hypotheses highlight the complexity of this relationship, with varying findings across different countries.

Research Methodology:

This study employs a meticulous investigation into the impact of fossil and renewable energy consumption on economic growth in BRICS nations spanning the period from 1995 to 2014. Carefully curated secondary data from reputable sources such as the World Bank and International Energy Administration form the backbone of this analysis. The analytical approach leans on the fixed effect model (FEM) and

least square dummy variable with panel data method, ensuring robust and nuanced insights.

In-Depth Analysis of Results:

The empirical findings unveil compelling insights into the energy-economic growth nexus in BRICS countries. While coal consumption emerges as a potent driver of economic growth, petroleum and natural gas consumption exhibit positive correlations, albeit with varying degrees of statistical significance. Intriguingly, the study reveals a short-term negative impact of renewable energy consumption on economic growth, underscoring the need for nuanced policy interventions.

Conclusion:

The complex interplay between energy consumption and economic growth in BRICS nations calls for a judicious balancing act. Coal remains a cornerstone in these emerging economies, fueling industrialization and propelling economic advancement. However, the surprising short-term negative impact of renewable energy consumption highlights the imperative for targeted investments and policies in sustainable energy sources.

As BRICS nations continue their trajectory of growth, the challenge lies in harmonizing the utilization of fossil fuels with the imperative for sustainable energy solutions. Future research should delve deeper into nuances such as energy type, environmental sustainability, and regulatory frameworks to provide a more comprehensive understanding of this intricate relationship. Only through such multifaceted analyses can we chart a path towards inclusive, sustainable, and robust economic growth in these dynamic nations.

Renewable Energy: The Case of the Arab Gulf Cooperation Council

Paper Review: "Barriers, Risks, and Opportunities of Investments in Renewable Energy Options in GCC States"

Introduction:

The paper under review discusses the evolving energy landscape in the Gulf Cooperation Council (GCC) countries and explores the barriers, risks, and opportunities associated with adopting renewable energy (RE) technologies in this region. The GCC, composed of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE), has historically been heavily dependent on fossil fuels for revenue and energy production. However, recent shifts in global energy trends, such as the 'Peak Oil' theory and climate change regulations, are compelling these nations to consider the adoption of RE options.

Strengths:

1. Timely and Relevant Topic: The paper addresses a highly relevant issue, considering the increasing global focus on sustainability and the transitioning energy landscape.

2. Clear Objectives: The objectives of the study are well-defined, and the paper effectively communicates its intent to explore the barriers, risks, and opportunities associated with RE adoption in GCC countries.

3. Data Sources: The paper relies on credible sources such as OPEC, IMF, and BP Statistical Review for data, enhancing the reliability of the analysis.

4. Methodology: The interpretive methodology employed is suitable for this exploratory research, allowing for a comprehensive analysis of the GCC energy landscape.

Areas for Improvement:

1. Literature Review: While the paper mentions a literature review, it doesn't provide a clear summary of the existing literature on the topic. A more in-depth literature review would help establish the context for the study and provide readers with a better

understanding of the existing knowledge on the subject.

2. Data Presentation: The paper lacks graphical representations, which could enhance the clarity of data presentation. Tables and figures could help visualize the share of RE in the energy mix, installed RE capacity, and other key data points.

3. Discussion of Findings: The paper briefly mentions that two GCC countries, the UAE and Qatar, are leading in RE adoption, while the others are making efforts. A more detailed discussion of the reasons behind these differences and the specific actions taken by each country would enrich the analysis.

4. Recommendations: The paper could benefit from a section dedicated to policy recommendations. Based on the findings, it should provide suggestions for policymakers in GCC countries to overcome barriers and leverage opportunities in the RE sector.

5. Clarity of Language: Some sentences are lengthy and complex, which may make the paper challenging to read. Simplifying sentence structure and improving overall clarity would enhance readability.

Conclusion:

The paper provides valuable insights into the evolving energy landscape in GCC countries and the challenges and opportunities associated with transitioning to renewable energy sources. However, to strengthen its contribution to the field, it should provide a more comprehensive literature review, visually represent data, delve deeper into the reasons behind variations in RE adoption among GCC states, offer policy recommendations, and improve overall clarity of language. These enhancements would make the paper more informative and accessible to a broader audience.

Detailed Discussion of the Research Findings:

The paper begins by highlighting the significance of the GCC, consisting of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE, in the global energy market due to its historical dependence on fossil fuels,

particularly oil and gas. It emphasizes the recent shifts in energy trends, such as the 'Peak Oil' theory and climate change regulations, which are motivating GCC countries to consider the adoption of renewable energy technologies.

Barriers to Renewable Energy Adoption:

The study identifies two significant short-term barriers to the successful deployment of renewable energy options in GCC countries. Firstly, the paper discusses the issue of subsidies on fossil fuels and electricity, which have traditionally hindered the economic viability of renewable energy sources. Removing these subsidies could make renewable energy more competitive in the market and lead to further economic development in GCC nations.

Secondly, the paper highlights bureaucracy as a real obstacle in GCC member states. Bureaucratic delays and cost overruns can impede renewable energy projects, affecting their overall feasibility. Streamlining bureaucratic processes and expediting necessary approvals for investors are essential steps in facilitating renewable energy adoption.

Share of Renewable Energy in the Total Energy Mix:

The paper analyzes the share of renewable energy in the total energy mix of GCC states. This analysis is crucial in understanding the current status of renewable energy adoption in the region. Currently, the share of renewable energy in the total energy mix is relatively low across GCC states. Notably, the UAE and Qatar are leading in this regard, with shares approximately equal to 1%, while Bahrain lags with the highest share being only 0.14%.

Future Energy and Economic Insecurities:

The study concludes by emphasizing the potential energy and economic insecurities that GCC states may face in the medium to long term. As global demand for fossil fuels diminishes due to climate change concerns, GCC countries, which have been major fossil fuel exporters, may encounter challenges in maintaining their energy and economic security. To mitigate these

risks, the paper strongly advises GCC states to invest heavily in renewable energy options, establishing a robust investment framework and supportive energy policies to encourage private and foreign direct investments in renewables. This approach can position GCC states as leaders in sustainable and green energy production.

Further Research and Conclusion:

The paper acknowledges the need for further research to quantify the opportunities of renewable energy investments in GCC states and to assess the opportunity cost of delaying such investments. This suggests a multi-disciplinary approach, involving engineering and business-related research expertise, to delve deeper into the economic implications of renewable energy adoption.

In conclusion, the paper offers valuable insights into the energy dynamics of GCC states and their transition toward renewable energy. By addressing the identified areas for improvement and enhancing its comprehensiveness, the paper can become an even more informative and influential resource in the field of renewable energy adoption in the Gulf Cooperation Council countries.

Conclusion

In a world marked by escalating environmental concerns and the urgent need for sustainable energy solutions, this comprehensive analysis illuminates the pivotal role of renewable energy in the Gulf Cooperation Council (GCC) nations. As Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE) navigate through a shifting energy landscape, the imperative for change becomes ever more evident.

The study underscores that renewable energy stands as the linchpin of a sustainable future. Its advantages, ranging from a significant reduction in carbon emissions to the promotion of sustainable development, are undeniable. As global trends reveal an increasing embrace of renewable energy sources, the GCC nations find themselves at the cusp of a transformative shift.

India, a nation witnessing rapid economic growth and an expanding population, faces the urgent need for sustainable energy solutions. The potential for renewable energy production is immense, and with ambitious targets set, India is poised to become a global leader in clean energy.

Delving into the complex interplay between energy consumption and economic growth, the BRICS nations emerge as economic powerhouses in transition. Recognizing the significance of both non-renewable and renewable energy sources in this context is pivotal for charting a course toward inclusive, sustainable, and robust economic growth.

The reviewed paper on renewable energy adoption in GCC countries provides valuable insights into the barriers, risks, and opportunities facing this dynamic region. While addressing areas for improvement, such as a more comprehensive literature review and enhanced data visualization, this research lays a solid foundation for understanding the evolving energy landscape in the GCC.

In conclusion, this body of work collectively underscores the urgency for a paradigm shift towards renewable energy. It is a call to action, not only for the GCC nations but for the global community at large, to embrace sustainable energy solutions as the cornerstone of a greener, more prosperous future. The path forward lies in strategic investments, policy innovation, and international collaboration to propel us towards a world powered by clean, renewable energy sources.

REFERENCES

1. Alhamrouni, O. A. Renewable Energy Policies and the Way Forward in GCC Countries. *Energy Strategy Reviews*, no. 34, 2021.
2. AlHorr Y. Barriers to renewable energy penetration in the GCC countries. *Renewable and Sustainable Energy Reviews*, no. 69, pp. 48-58, 2017.
3. International Energy Agency. *Renewables 2020: Analysis and forecast to 2025*. IEA Publications, 2020.

4. Kasim, S., & Duffuaa, S. O. Renewable energy development in GCC countries: A framework for policy formulation and analysis. *Renewable and Sustainable Energy Reviews*, no, 42, pp. 1034-1043, 2015.
5. Ministry of Energy & Industry, UAE. UAE Energy Strategy 2050. Retrieved from <https://www.moEI.gov.ae/en/our-services/plans-strategies-and-projects/national-energy-strategy-2050.aspx>, 2020.
6. Motasemi, F., & Afzal, S. An overview of renewable energy utilization in the oil-rich GCC countries. *Renewable and Sustainable Energy Reviews*, no. 60, pp.775-782, 2016.
7. Price, L., & Bogach, V. Renewable energy prospects for the Gulf Cooperation Council (GCC) states. *Energy Policy*, no. 127, pp. 280-292, 2019.
8. Reiche, D. The political economy of renewable energy in the Gulf Cooperation Council countries: The case of solar energy. *Energy Policy*, no. 93, pp. 255-263, 2019.
9. UN Environment. The Transition to Renewable Energy in the Gulf Region: Is the business case changing? <https://www.unenvironment.org/resources/report/transition-renewable-energy-gulf-region-business-case-changing>, 2019.
10. World Bank. GCC Countries - Renewable Energy Readiness Assessment Report. Retrieved from <https://www.worldbank.org/en/news/report/2021/09/08/gcc-countries-renewable-energy-readiness-assessment-report>, 2021.

