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COMPARATIVE STUDY OF RENEWABLE ENERGY POLICIES OF INDIA, CHINA AND THE USA

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A. LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL FORMS
USA	United States Of America
MNRE	Ministry Of New And Renewable Energy
NEA	National Energy Administration
EIA	Energy Information Administration
ITA	Investment Tax Credit
IRENA	International Renewable Energy Agency
NDRC	National Development And Reform Commission
NCSL	National Conference Of State Legislatures
PTC	Production Tax Credit
RPO	Renewable Purchase Obligations
GW	Gigawatt
ACORE	American Council of Renewable Energy
RPS	Renewable Portfolio Standards

A. Abstract

The global transition to renewable energy sources has gained significant attention due to concerns over climate change and energy security. The objective of this study is to present a thorough comparative analysis of the renewable energy policies adopted in India, China, and the US. The research looks at each nation's policy frameworks, objectives, incentives, and difficulties in developing renewable energy. This research attempts to uncover key indicators of success and lessons gained that may guide policy formulation and promote sustainable renewable energy transitions globally by examining the experiences of these three large economies. To give a comprehensive grasp of the issue, the research employs a variety of qualitative methodologies, including a literature review, policy analysis, and case studies. The findings of this study will contribute to the knowledge base on renewable energy policy effectiveness and offer valuable insights for policymakers, researchers, and stakeholders in the field of sustainable energy.

Keywords:-Renewable energy, India, China, USA, Policies, Sustainable energy.

1. INTRODUCTION

The world is shifting towards using renewable energy sources to address important issues like climate change, energy security, and sustainable development. Renewable energy policies play a crucial role in promoting the use of clean and sustainable energy technologies. This research paper focuses on comparing the renewable energy policies of three major countries: India, China, and the United States. State. These three countries are among the largest energy consumers globally and have made commitments to increase their use of renewable energy. Each country has different approaches, energy landscapes, and social-economic contexts making them valuable cases to study.

By comparing their renewable energy policies, the aims is to understand what works well, identify key factors for success, and provide recommendations to speed up the adoption of renewable energy worldwide. This research has two main goals. First, we will analyze the policies and regulations established in India, China, and the United States to support renewable energy. This will involve looking at the laws, rules, and organizations that encourage the use of renewable energy technologies. Second, we will evaluate the targets, incentives, and support systems used by these countries to promote renewable energy. We want to understand how effective these measures have been in driving the development of renewable energy sources.

By understanding what works and what doesn't in India, China, and the United States, countries worldwide can learn from their experiences and adopt strategies to speed up the use of renewable energy technologies. This will help us move towards a cleaner and more sustainable energy future.

1.1. Background and Significance

The need to reduce greenhouse gas emissions and shift towards cleaner, more sustainable energy sources has become a pressing priority. Renewable energy, including solar, wind, hydro, and bioenergy, has emerged as a viable alternative to fossil fuels. India, China, and the United States are among the largest energy consumers globally and have made significant commitments to increasing the share of renewable energy in their energy mixes. The renewable energy policies adopted by these countries have the potential to influence global efforts to combat climate change and transition towards a low-carbon economy. By studying and comparing the policies of these countries, valuable insights can be gained to inform and improve renewable energy policies worldwide.

2. Renewable Energy Policies: An Overview

2.1. India

India has immense renewable energy potential, including solar, wind, biomass, and hydro resources¹. To encourage the use of renewable energy, the nation has put in place a number of policies and projects. By 2022, 100 GW of solar power capacity is the goal of the National Solar Mission, which was started in 2010². In addition, the National Wind-Solar Hybrid Policy supports the creation of projects that integrate solar and wind energy. These laws, together with several financial incentives and tax breaks, have helped India's renewable energy capacity increase quickly. Despite significant progress, India faces challenges in integrating renewable energy into its grid due to issues such as grid stability, land availability, and financial viability². Reliable power delivery is further hampered by the sporadic nature of renewable energy sources. The government

¹ Ministry of New and Renewable Energy (MNRE), "Renewable Energy Potential," Government of India,

² Ministry of New and Renewable Energy (MNRE), "National Solar Mission," Government of India.

² Ministry of New and Renewable Energy (MNRE), "National Wind-Solar Hybrid Policy," Government of India ⁵
National Energy Administration (NEA), "China's Renewable Energy Consumption," National Energy Administration,

is actively addressing these challenges through reforms in grid infrastructure, policy enhancements, and innovative financing mechanisms.

2.2. China

The world's top user and producer of renewable energy in China.⁵The nation is endowed with considerable renewable energy resources, especially in the fields of wind and solar energy. The two objectives of lowering pollution and developing China's domestic clean energy sector are what motivate the country's renewable energy policies³. To encourage the growth of renewable energy, the government has put in place supporting policies including feed-in tariffs, renewable portfolio requirements, and advantageous tax incentives⁴.China has achieved outstanding strides in the deployment of renewable energy, exceeding its own goals and rising to the position of a global leader in renewable energy capacity⁵. However, challenges remain, including curtailment issues, grid integration, and the need for market reforms to ensure a more sustainable renewable energy sector.

2.3. United States

The United States has a diverse renewable energy landscape, with abundant solar, wind, biomass, and geothermal resources. To encourage the use of renewable energy, the nation has enacted a variety of federal, state, and municipal laws. At the federal level, the Investment Tax Credit (ITC) and the Production Tax Credit (PTC) have played a crucial role in incentivizing renewable energy projects⁶. In order to impose a specific amount of renewable energy in their mix of power generation, some states have also introduced Renewable Portfolio Standards (RPS)⁷.Although the potential for renewable energy in the United States has grown significantly; there are still issues with policy uncertainty, regulatory restrictions, and the sporadic nature of renewable sources⁸.

³ X. Zhang, J. F. Mercure, P. B. Holden, and U. Salas, "The Role of China in Mitigating Climate Change," *Nature Communications*, vol. 11, no. 1, p. 4623, Sep. 2020

⁴ National Development and Reform Commission (NDRC), "China's Policies and Actions for Addressing Climate Change," National Development and Reform Commission,

⁵ International Renewable Energy Agency (IRENA), "Renewable Capacity Statistics 2021

⁶ U.S. Department of Energy (DOE), "Investment Tax Credit (ITC) for Solar Photovoltaic Systems," U.S. Department of Energy.

⁷ National Conference of State Legislatures (NCSL), "Renewable Portfolio Standards," National Conference of State Legislatures,

⁸ U.S. Energy Information Administration (EIA), "Renewable Energy Explained: Challenges of Renewable Energy," U.S. Energy Information Administration.

However, several jurisdictions have shown leadership in the adoption of renewable energy, offering helpful examples of successful policy implementation and innovation.

3. Comparative Analysis of Renewable Energy Policies

Renewable energy policies play a crucial role in shaping the deployment and integration of renewable energy technologies. This section provides a comparative analysis of the renewable energy policies implemented in India, China, and the United States, focusing on policy frameworks, targets, and incentives

3.1. Policy Framework

The policy framework adopted by India, China and the USA reflects their unique socio-economic context and priorities India's policy framework for renewable energy is primarily governed by the Electricity Act of 2003, the National Electricity Policy of 2005, and the National Action Plan on Climate Change. The policy emphasizes the development of renewable energy through various measures, including the promotion of off-grid renewable energy systems, net metering, and the creation of Renewable Purchase Obligations (RPOs) for electricity distribution companies. The Ministry of New and Renewable Energy (MNRE) plays a key role in formulating and implementing renewable energy policies.

China's policy framework for renewable energy is driven by the Renewable Energy Law, which was enacted in 2005 and revised in 2018. The law establishes a comprehensive framework to support the development and utilization of renewable energy sources. China has adopted a top down approach, setting ambitious renewable energy targets and implementing a mix of market based mechanisms, including feed-in tariffs (FITs), green certificate trading schemes, and quota systems. The National Energy Administration (NEA) is responsible for coordinating and implementing renewable energy policies.

The United States has a decentralized policy framework, with federal, state, and local governments playing significant roles. The federal level policies include tax incentives, research and development programs, and environmental regulations. At the state level, Renewable Portfolio Standards (RPS) set targets for renewable energy adoption, while other policies, such as feed-in tariffs and net metering, are implemented at the state or local level. The Department of Energy

(DOE) and the Environmental Protection Agency (EPA) are key federal agencies involved in shaping and implementing renewable energy policies.

3.2. Renewable Energy Targets

Renewable energy targets provide a roadmap for countries to increase the share of renewable energy in their energy mix. India has set a target of achieving 450 gig watts (GW) of renewable energy capacity by 2030. This includes 280 GW from solar power, 140 GW from wind power, and 30 GW from other renewable sources. These targets represent a significant scaling up of India's renewable energy ambitions and require substantial investments and policy support to achieve⁹.

China¹⁰ has set a target of reaching a renewable energy capacity of 1,200 GW by 2030. This includes 680 GW from wind power, 510 GW from solar power, and 10 GW from other renewable sources. These targets demonstrate China's commitment to renewable energy and its aim to establish itself as a global leader in clean energy technologies.

The United States¹¹ does not have a single national renewable energy target. Instead, renewable energy targets vary across states and are set through Renewable Portfolio Standards (RPS) or other state-level policies. By analyzing the policy frameworks and renewable energy targets in India, China, and the United States, this research provides a comparative understanding of the approaches and ambitions of each country in promoting renewable energy adoption. It highlights the similarities and differences in policy priorities, mechanisms, and targets, paving the way for the assessment of policy effectiveness and the identification of key success factors and challenges.

4. Achievements and Challenges

India has made significant achievements in renewable energy deployment. The country has witnessed substantial growth in solar and wind power capacity, surpassing several milestones in recent years. India has become one of the world's largest renewable energy markets, attracting

⁹ Ministry of New and Renewable Energy (MNRE). "Renewable Energy Policy of India", Government of India

¹⁰ National Energy Administration (NEA). "Renewable Energy Law of the People's Republic of China (2018 Revision)."

¹¹ U.S. Department of Energy (DOE). "Renewable Energy Policies and Incentives."

Significant investments and driving job creation in the sector. The introduction of favorable policies, such as competitive bidding for renewable energy projects and the establishment of solar parks, has facilitated cost reduction and accelerated deployment. Furthermore, initiatives like the International Solar Alliance, launched by India, have enhanced global cooperation in advancing renewable energy adoption.

China has emerged as a global leader in renewable energy deployment. The country has achieved remarkable success in expanding its solar and wind power capacity, surpassing its own targets. China's rapid scale-up of renewable energy technologies has resulted in significant reductions in greenhouse gas emissions and air pollution. Moreover, the country's manufacturing prowess and economies of scale have contributed to cost reductions, making renewable energy increasingly competitive. China's achievements in renewable energy deployment have also positioned it as a key player in global renewable energy markets. The United States has witnessed substantial achievements in renewable energy deployment at the state and regional levels. Several states have made significant progress in increasing their renewable energy capacity and reducing carbon emissions. The growth of renewable energy in the United States has been driven by falling technology costs, supportive policies, and increased public awareness of climate change. The country has also experienced significant job creation in the renewable energy sector, contributing to economic growth and sustainability.

Despite its achievements, India faces several challenges in the renewable energy sector. The intermittent nature of renewable energy sources poses integration challenges into the grid, requiring the development of robust grid infrastructure and energy storage systems. Land acquisition, regulatory barriers, and bureaucratic processes can delay project implementation. Financing barriers, including access to affordable capital, remain a concern, particularly for small and medium-sized projects. Additionally, ensuring the financial viability and sustainability of renewable energy programs, such as feed-in tariffs and subsidies, poses a challenge to the government. China faces challenges in optimizing the integration of renewable energy into its existing energy system. The curtailment of renewable energy, particularly in remote regions, remains an issue due to inadequate transmission and distribution infrastructure.

The variability of renewable energy sources also poses challenges to grid stability and requires advanced grid management and energy storage technologies. Furthermore, the rapid growth of the renewable energy sector has led to concerns about overcapacity, economic viability, and the quality

of installations, highlighting the importance of effective regulation and oversight. In the United States, challenges in renewable energy deployment vary across states and regions. Regulatory and permitting processes can be complex and time-consuming, hindering project development. The intermittent nature of renewable energy sources requires robust grid infrastructure and energy storage solutions to ensure reliable and efficient operation. The availability of long-term policy support and incentives is crucial to providing stability and attracting investments in the sector. Additionally, the political and policy landscape at the federal level can impact the growth and continuity of renewable energy initiatives.

5. Future Perspectives

In the future, India's renewable energy sector is expected to continue its growth trajectory. The government's commitment to achieving 450 GW of renewable energy capacity by 2030 demonstrates its ambitious vision. To further enhance renewable energy deployment, it is crucial for India to focus on addressing the existing challenges. This includes improving grid infrastructure and investing in energy storage technologies to ensure grid stability and manage intermittent renewable energy generation¹². Furthermore, streamlining bureaucratic processes, simplifying land acquisition procedures, and promoting innovative financing mechanisms can help attract more investments in the sector¹⁶. China is likely to maintain its leadership position in renewable energy deployment in the coming years.

The country's emphasis on technology innovation and research and development will continue to drive advancements in renewable energy technologies. To address challenges related to grid integration and curtailment, China should focus on strengthening its transmission and distribution

¹² Ministry of New and Renewable Energy (MNRE). "*Renewable Energy Policy of India*" Government Of India

¹⁶ TERI, 2020

Infrastructure and implementing advanced grid management systems¹³. Moreover, ensuring the economic viability of renewable energy projects and establishing mechanisms to address overcapacity concerns will be crucial for the long-term sustainability of the sector¹⁴.

The future of renewable energy in the United States will be influenced by policy decisions and market dynamics. Continued support at the federal and state levels is essential to provide long term stability and attract investments in renewable energy. The expansion of grid infrastructure, including the development of smart grids and energy storage systems, will enhance the integration of renewable energy sources¹⁵ Furthermore, fostering research and development initiatives and promoting collaboration between public and private sectors will drive technology advancements and cost reductions¹⁶.

6. Recommendations

Based on the comparative analysis and future perspectives, the following recommendations can be made like, Strengthen Policy Frameworks: All three countries should continue to strengthen their policy frameworks by providing long-term targets, stable regulatory environments, and financial incentives to promote renewable energy deployment. Regular evaluations and revisions of policies should be conducted to align with evolving market dynamics and technological advancements.

Enhancing grid infrastructure, including transmission and distribution systems, is crucial to accommodate the growing penetration of renewable energy. This includes expanding transmission networks, implementing advanced grid management technologies, and investing in energy storage systems to balance supply and demand¹⁷. Governments should prioritize investments in research and development to drive technology advancements and cost reductions in renewable energy technologies. Collaboration between academia, industry, and research institutions can help foster

¹³ National Energy Administration, 2021

¹⁴ International Renewable Energy Agency (IRENA), "*Renewable Capacity Statistics* ,2020

¹⁵ IRENA International Renewable Energy Agency (IRENA), "*Renewable Capacity Statistics 2021*,*American Council Of Renewable Energy*,2021

¹⁶ American Council Of Renewable Energy,2021

¹⁷ International Renewable Energy Agency (IRENA), "*Renewable Capacity Statistics*"2019

Innovation and facilitate the commercialization of new technologies¹⁸. Collaboration among countries, such as knowledge sharing, technology transfer, and joint research initiatives, can accelerate renewable energy deployment globally. Countries can learn from each other's experiences, best practices, and challenges to foster a sustainable energy transition. By implementing these recommendations countries can further enhance their renewable energy and address the challenges faced in the sector. This will contribute to a more sustainable and secure energy future, reducing greenhouse gas emissions and promoting economic growth and energy access for all¹⁹.

7. Conclusion

The comparative analysis of renewable energy policies in India, China, and the United States provides valuable insight into the approaches taken by these countries in promoting renewable energy development. Despite the difference in the policy framework, all these countries have made significant achievement in expanding their renewable energy capacities and driving the transition to clean energy sources. India has demonstrated its commitment to renewable energy through ambitious targets and supportive policies. The country's focus on decentralized energy production, rural electrification, and international collaborations has contributed to its renewable energy success. China's rapid scale-up of renewable energy, driven by strong policy support, technology advancements, and economies of scale, has positioned it as a global leader in the sector. The United States, with its diverse policy landscape and supportive market incentives, has seen substantial growth in renewable energy deployment at the state and regional levels while each country has faced its own set of challenges, such as grid integration issues, regulatory barriers, and financing constraints, they have also identified valuable lessons. The importance of long-term targets, stable policy frameworks, and coordination among various stakeholders has been emphasized.

¹⁸ American Council Of Renewable Energy 2021

¹⁹ Ministry of New and Renewable Energy (MNRE). "*Renewable Energy Policy of India*", Government of India, 2022.

Looking ahead, it is crucial for these countries to continue strengthening their policy frameworks, improving grid infrastructure, fostering innovation and research, and promoting international collaboration. By implementing these recommendations, India, China, and the United States can further accelerate their renewable energy transitions and contribute to global efforts in combating climate change and achieving sustainable development goals.

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