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Assessing the Role of Renewable Energy Policies in Achieving India's Sustainable Development Goals by 2047

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ABSTRACT

India's journey towards sustainable development is mostly depends on its renewable energy and renewable energy policies, which are central to achieving the India's Sustainable Development Goals (SDGs). This research paper provides a comprehensive analysis of the impact of India's renewable energy initiatives on the India's progress towards SDGs goals. It also evaluates the effectiveness of current policies, and identifies existing challenges, and explores the potential for future opportunities of expansion in the renewable energy sector. The study emphasizes the need for policy refinement, technological innovation, and strategic interventions to overcome barriers and ensure that India not only meets but exceeds its sustainability targets by 2047—the centenary of its independence. This timeline is crucial as it represents a significant milestone in India's commitment to becoming a global leader in sustainable energy and development.

Keywords: *Renewable Energy, Sustainable Development Goals, Energy Policies, Environmental Sustainability, Carbon Emissions.*

1. INTRODUCTION

The India, world's third-largest energy consumer and 2nd most populated counry, stands at a critical point in its development path (International Energy Agency [IEA], 2020). India is one of the fastest-growing country in terms of economies, India's energy demand is also expected to increase Significatly in the coming years, because of rapid urbanization, industrialization, and population growth (Ministry of New and Renewable Energy [MNRE], 2021). This rising demand presents a significant challenges: how to sustain economic growth while simultaneously addressing the hitting need for environmental sustainability (Schwerhoff & Sy, 2017). The country's development path, if depends on traditional fossil fuels, could cause environmental damage, and will contribute to global climate change, and undermine long-term sustainable development efforts (IEA, 2020). Consequently, India faces the dual challenge of developing economic growth while ensuring that this growth is environmentally sustainable and inclusive (MNRE, 2021). In recognition of these challenges, India has committed to an dedicated agenda to transform its energy sector (MNRE, 2021). Central to this transformation is the widely adoption of renewable energy (RE) resources, which are seen as essential to reducing carbon emissions, enhancing energy security, and promoting sustainable development (International Renewable Energy Agency [IRENA], 2019). India's renewable energy journey began in earnest with the launch of the National Action Plan on Climate Change (NAPCC) in 2008, which laid the groundwork for the subsequent expansion of renewable energy capacity across the country (Government of India, 2008). This commitment was further solidified with the Paris Agreement in 2015, where India pledged to increase the share of non-fossil fuel energy sources to 40% of its total energy mix by 2030 (IEA, 2020). The country's renewable energy policies have since evolved, aiming to accelerate the deployment of solar, wind, hydro, and biomass energy, thereby reducing the carbon intensity of its economy (MNRE, 2021). One of the most significant milestones in India's renewable energy agenda is the target to achieve 175 GW of installed renewable energy capacity by 2022, which includes 100 GW from solar power, 60 GW from wind, 10 GW from bio-power, and 5 GW from small hydro-power (MNRE, 2021). This target has been further escalated, with the government announcing a new target of 450 GW by 2030, reflecting India's determination to lead in the global renewable energy landscape (IEA, 2020). Solar energy, in particular, has been at the forefront of this renewable energy push, with India emerging as one of the largest solar markets in the world (IRENA, 2019). The International Solar Alliance (ISA), an initiative led by India and France, underscores India's commitment to fostering international cooperation in solar energy and leveraging its potential to drive global energy transitions (ISA, 2020).

However, the ambitious renewable energy targets are not just about enhancing energy security and reducing emissions (MNRE, 2021). They are integral to India's broader development objectives, encapsulated in the Sustainable Development Goals (SDGs) adopted by the United Nations (United Nations, 2015). India has identified renewable energy as a crucial element in achieving several SDGs, particularly SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), and SDG 9 (Industry, Innovation, and Infrastructure) (IEA, 2020). By promoting renewable energy, India aims to not only reduce its greenhouse gas emissions but also to create jobs, improve public health by reducing air pollution, and enhance energy access in rural and remote areas (MNRE, 2021). This aligns with the government's vision of inclusive growth, where economic development benefits all sections of society while minimizing environmental harm (Schwerhoff & Sy, 2017). The timeline leading up to 2047, which will mark the centenary of India's independence, is particularly significant (IEA, 2020). The Indian government has set its sights on this milestone as a key target date for achieving its SDGs, with renewable energy playing a pivotal role in this endeavour (MNRE, 2021). The vision for 2047 encompasses a sustainable, resilient, and inclusive energy system that supports India's development goals while ensuring that the benefits of growth are distributed equitably across its population (MNRE, 2021). This vision includes transitioning to a low-carbon economy, reducing dependence on imported fossil fuels, and enhancing energy security through diversified energy sources (IRENA, 2019).

Despite the robust policy framework and the rapid growth in renewable energy capacity, India faces several challenges in realizing its renewable energy ambitions (IEA, 2020). These include financial constraints, infrastructural limitations, regulatory and policy hurdles, and the need for technological innovation to enhance the efficiency and reliability of renewable energy systems (MNRE, 2021). Additionally, integrating a high share of renewables into the national grid requires significant upgrades to transmission infrastructure, the development of energy storage solutions, and the implementation of smart grid technologies (Central Electricity Authority [CEA], 2020). Addressing these challenges is crucial to ensuring that renewable energy can meet a growing share of India's energy needs while supporting the country's broader development objectives (Schwerhoff & Sy, 2017). As India approaches the centenary of its independence, the country is poised to become a global leader in renewable energy (IEA, 2020). The successful implementation of its renewable energy policies is not only critical for achieving the SDGs but also for ensuring long-term energy security, economic growth, and environmental sustainability (MNRE, 2021). This research paper will explore the various dimensions of India's renewable energy journey, analysing the policies, challenges, and opportunities that lie ahead as the nation strives to fulfilled its ambitious energy and development goals by 2047 (IRENA, 2019).

2. THE ROLE OF RENEWABLE ENERGY IN SUSTAINABLE DEVELOPMENT

Renewable energy plays a pivotal role in the global quest for sustainable development, offering a sustainable and environmentally friendly alternative to fossil fuels. As the world grapples with the consequences of climate change, the shift towards renewable energy sources has become increasingly urgent. This transition is essential not only for reducing greenhouse gas emissions but also for ensuring long-term energy security and fostering economic growth. Renewable energy, by its very nature, harnesses natural processes such as sunlight, wind, and water flow, which are both abundant and renewable, making it a key component of a sustainable future.

The significance of renewable energy is underscored by the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 and SDG 13. SDG 7 is dedicated to ensuring access to affordable, reliable, sustainable, and modern energy for all by 2030. It highlights the importance of expanding renewable energy use, improving energy efficiency, and promoting investment in energy infrastructure and clean energy technologies (United Nations, 2015). Achieving this goal is seen as critical for broader sustainable development efforts, as energy access is directly linked to economic growth, poverty reduction, health improvements, and education. Meanwhile, SDG 13 calls for urgent action to combat climate change and its impacts, emphasizing the need for a rapid transition to low-carbon energy systems to mitigate global warming and its associated risks (United Nations, 2015).

India, as one of the world's largest and most populous countries, faces the formidable challenge of meeting its growing energy demand while also fulfilling its international commitments to combat climate change. Recognizing the central role of energy in achieving sustainable development, India has implemented a series of ambitious renewable energy policies. These policies are designed to align with the SDGs, focusing on the development and expansion of solar, wind, hydro, and biomass energy sources to create a more sustainable and resilient energy mix.

India's renewable energy strategy is driven by its commitment to reducing greenhouse gas emissions and enhancing energy security. By shifting away from fossil fuels, India aims to decrease its reliance on imported energy, thereby improving its energy independence and economic stability. The country's National Action Plan on Climate Change (NAPCC), launched in 2008, set the stage for this transformation by establishing the National Solar Mission, which aims to promote the development of solar energy technologies and achieve large-scale deployment of solar power (Government of India, 2008). This initiative was followed by several other programs targeting wind, hydro, and biomass energy, all of which are integral to achieving India's renewable energy goals.

The expansion of solar energy has been particularly notable. India has emerged as one of the leading countries in solar energy capacity, with the goal of achieving 100 GW of installed solar capacity by 2022 (Ministry of New and Renewable Energy,

2021). This ambitious target is part of a broader objective to increase the share of renewable energy in the country's total energy mix to 40% by 2030, as committed under the Paris Agreement (International Energy Agency, 2020). The success of these initiatives is crucial for achieving SDG 7, as they directly contribute to expanding access to affordable and clean energy for millions of people, particularly in rural and underserved areas.

In addition to solar energy, India has also made significant strides in the development of wind energy. The country ranks fourth globally in wind energy capacity, with over 38 GW of installed capacity as of 2020 (Global Wind Energy Council, 2020). Wind energy is seen as a complementary resource to solar energy, particularly in regions where wind speeds are favorable for power generation. The integration of wind energy into the national grid has the potential to further diversify India's energy portfolio and enhance its overall energy security.

Hydropower and biomass energy are also critical components of India's renewable energy strategy. Small hydro projects, particularly in the hilly regions, offer a reliable source of energy with minimal environmental impact. Meanwhile, biomass energy, which includes the use of agricultural residues, forest waste, and other organic materials, provides a renewable source of energy that can support rural development and reduce waste (Ministry of New and Renewable Energy, 2021). These energy sources not only contribute to the reduction of greenhouse gas emissions but also support the livelihoods of rural communities, thereby aligning with multiple SDGs, including SDG 1 (No Poverty) and SDG 8 (Decent Work and Economic Growth).

India's renewable energy policies are not just a response to domestic energy needs but also a part of its broader commitment to global climate action. By investing in renewable energy, India is taking proactive steps to meet its Nationally Determined Contributions (NDCs) under the Paris Agreement, which include reducing the emissions intensity of its GDP by 33-35% by 2030 from 2005 levels (Government of India, 2015). These efforts are critical for achieving SDG 13, as they contribute to global efforts to limit temperature rise and mitigate the impacts of climate change.

Renewable energy is central to India's sustainable development strategy, aligning closely with the goals set out in the United Nations' SDG framework. Through its comprehensive renewable energy policies, India is working to create a more sustainable, resilient, and equitable energy system. This research paper will explore India's renewable energy journey in detail, examining the policies, challenges, and opportunities that lie ahead as the country strives to meet its SDG commitments and contribute to global efforts to combat climate change.

3. INDIA'S RENEWABLE ENERGY POLICIES: AN OVERVIEW

India's commitment to renewable energy has been a central component of its broader strategy to meet growing energy demands, ensure energy security, and mitigate environmental impacts associated with conventional energy sources. This commitment was institutionalized with the establishment of the Ministry of New and Renewable Energy (MNRE) in 1992, marking the formal beginning of India's renewable energy journey. Since its inception, MNRE has played a pivotal role in formulating and implementing policies aimed at scaling up renewable energy production across the country, with a focus on harnessing solar, wind, biomass, and small hydro resources.

The National Solar Mission (NSM): One of the cornerstone initiatives of India's renewable energy policy framework is the National Solar Mission (NSM), also known as the Jawaharlal Nehru National Solar Mission (JNNSM). Launched in 2010 as part of the National Action Plan on Climate Change (NAPCC), the NSM set an ambitious target of deploying 20 GW of grid-connected solar power by 2022. However, recognizing the vast potential of solar energy in India and the rapid advancements in solar technology, this target was subsequently revised in 2015, with the government setting a new goal of achieving 100 GW of solar power by 2022 (MNRE, 2015).

The NSM is structured around three phases, each aimed at progressively increasing the country's solar power capacity. The first phase (2010-2013) focused on creating an enabling policy framework and promoting research and development in solar technology. The second phase (2013-2017) aimed to scale up deployment and reduce costs through competitive bidding processes and the development of large-scale solar parks. The third phase (2017-2022) emphasized further scaling up and integrating solar power into the national grid, with a strong focus on decentralized solar generation and rooftop solar installations (MNRE, 2015).

Under the NSM, various policy instruments have been introduced to support the solar sector. These include feed-in tariffs, viability gap funding, capital subsidies, and renewable purchase obligations (RPOs) for state utilities. The NSM has also fostered public-private partnerships, attracting significant investment from both domestic and international players. As a result, India has emerged as one of the world's largest solar markets, with solar energy capacity growing from a mere 2.6 GW in 2014 to over 40 GW by 2021, making substantial progress towards the 100 GW target (MNRE, 2021).

The National Wind Energy Mission (NWEM): In parallel with its solar initiatives, India has also been a global leader in wind energy, with the National Wind Energy Mission (NWEM) playing a crucial role in this domain. Launched in 2015, the NWEM set a target of achieving 60 GW of wind power capacity by 2022 (MNRE, 2015). The mission aims to capitalize on India's significant wind energy potential, particularly in states like Tamil Nadu, Gujarat, Maharashtra, and Karnataka, which

have favorable wind conditions.

The NWEM's approach includes enhancing wind resource assessment, simplifying land acquisition processes, and improving grid infrastructure to accommodate large-scale wind power integration. The mission also emphasizes the repowering of older wind turbines to enhance efficiency and output, as well as the promotion of offshore wind energy projects. Policy instruments under the NWEM include feed-in tariffs, reverse auctions for wind power projects, and fiscal incentives such as accelerated depreciation and generation-based incentives (MNRE, 2015). India's wind energy sector has seen remarkable growth, with installed capacity increasing from 21 GW in 2012 to over 38 GW by 2021. The country's focus on wind energy has not only contributed to its renewable energy mix but has also spurred the development of a robust wind turbine manufacturing industry, creating jobs and fostering technological innovation (MNRE, 2021).

The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) Scheme: Recognizing the importance of decentralized renewable energy generation, especially in rural areas, the Government of India launched the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme in 2019. The PM-KUSUM scheme is designed to promote solar energy generation among farmers, with the dual objectives of enhancing agricultural productivity and improving energy access in rural India (MNRE, 2019).

The PM-KUSUM scheme has three main components: (1) installation of standalone solar-powered irrigation pumps, (2) solarization of existing grid-connected pumps, and (3) setting up of decentralized solar power plants up to 2 MW capacity on barren lands. By incentivizing farmers to install solar pumps, the scheme aims to reduce their dependency on grid electricity and diesel, thereby lowering their energy costs and reducing carbon emissions. The solarization of grid-connected pumps, on the other hand, allows farmers to generate surplus electricity, which can be sold to the grid, providing them with an additional source of income (MNRE, 2019).

The decentralized solar power plants under PM-KUSUM are intended to be set up on barren or fallow land, which otherwise remains unproductive. These small-scale power plants can generate clean energy, contributing to rural electrification and reducing transmission losses associated with power supply in remote areas. The scheme also has a strong focus on sustainability, ensuring that the transition to solar energy is economically viable for farmers and does not adversely impact agricultural productivity (MNRE, 2019).

India's renewable energy policies, as embodied by initiatives like the National Solar Mission, the National Wind Energy Mission, and the PM-KUSUM scheme, demonstrate the country's commitment to transitioning towards a sustainable and low-carbon energy future. These policies not only contribute to reducing carbon emissions and enhancing energy security but also play a crucial role in promoting sustainable development across various sectors. As India continues to pursue its ambitious renewable energy targets, these initiatives are expected to play a pivotal role in achieving the Sustainable Development Goals (SDGs) and ensuring a sustainable energy future for the country.

4. IMPACT OF RENEWABLE ENERGY POLICIES ON SDGS

India's renewable energy policies have significantly impacted its progress towards the SDGs. The expansion of renewable energy capacity has contributed to a reduction in carbon emissions, aligning with SDG 13 (Ministry of Environment, Forest and Climate Change [MoEFCC], 2020). Furthermore, the increase in energy access, particularly in rural areas, supports SDG 7 by providing affordable and clean energy to underserved populations (International Energy Agency [IEA], 2021). However, challenges such as financial constraints, grid integration issues, and land acquisition disputes continue to hinder the full realization of these benefits (Bhattacharya & Patel, 2020).

5. CHALLENGES AND OPPORTUNITIES IN SCALING UP RENEWABLE ENERGY IN INDIA

Challenges

Financing and Investment Needs: One of the most significant challenges in scaling up renewable energy in India is financing. The transition to a sustainable energy system requires substantial capital investment in infrastructure, technology, and human resources. Renewable energy projects, especially large-scale solar and wind farms, involve high upfront costs, even though their operational expenses are relatively low. Securing the necessary financial resources is challenging, particularly in a developing country like India, where budgetary constraints are a persistent issue. Traditional financial institutions are often reluctant to finance renewable energy projects due to perceived risks such as technology obsolescence, policy changes, and the long payback periods associated with such investments (Ghosh & Nanda, 2021).

To address these financial challenges, India needs to strengthen its mechanisms for mobilizing capital, particularly through public-private partnerships (PPPs) and international collaborations. PPPs can play a crucial role by leveraging private sector efficiency, technology, and capital with public sector support, thereby mitigating risks and enhancing project viability. International financial institutions and development banks can also provide much-needed funding, particularly in the form of concessional loans, grants, and equity investments. Moreover, innovative financial instruments such as green bonds and climate funds are increasingly being utilized to channel private investments into the renewable energy sector, though their

potential has yet to be fully realized in India (Ghosh & Nanda, 2021).

Grid Integration

Another significant challenge facing India's renewable energy expansion is grid integration. The inherent intermittency of renewable energy sources like solar and wind—caused by their dependence on weather conditions—poses challenges for maintaining grid stability and reliability. Unlike conventional power plants, which can generate electricity consistently, solar and wind energy production fluctuates with changes in sunlight and wind speeds. This variability makes it difficult to balance supply and demand on the grid, leading to potential issues such as frequency fluctuations, voltage instability, and even blackouts if not managed properly (Chattopadhyay et al., 2020).

To overcome these challenges, India must invest in advanced grid management systems that can accommodate a higher share of renewable energy. This includes the development of smart grids, which use digital communication technology to monitor and manage the production, distribution, and consumption of electricity more effectively. Energy storage solutions, such as batteries, are also crucial, as they can store excess electricity generated during periods of high renewable output and release it when production is low. Additionally, grid upgrades and the expansion of transmission infrastructure are necessary to connect remote renewable energy sites to the national grid and to manage the variability of renewable energy sources more effectively (Chattopadhyay et al., 2020).

Land Acquisition

Land acquisition for large-scale renewable energy projects is another challenge that has sparked conflicts in various parts of India. The establishment of solar parks and wind farms requires large tracts of land, often in rural or semi-rural areas. This can lead to displacement of local communities, loss of agricultural land, and environmental degradation, which in turn can trigger resistance from affected populations. In many cases, the lack of transparent and inclusive land acquisition processes has exacerbated these conflicts, leading to delays in project implementation and increased costs (Sharma et al., 2019).

To address these issues, it is essential to adopt more inclusive and participatory approaches to land use planning. This involves engaging with local communities early in the project planning process, ensuring fair compensation for landowners, and exploring alternative land use models that minimize displacement and environmental impact. For instance, agrovoltaic systems, which combine solar power generation with agricultural production, offer a way to utilize land for both energy and food production, thereby reducing land use conflicts. Additionally, government policies should promote the use of degraded or non-arable land for renewable energy projects, which can help mitigate the social and environmental impacts associated with land acquisition (Sharma et al., 2019).

Opportunities

Declining Costs of Renewable Technologies: Despite the challenges, the renewable energy sector in India presents significant opportunities for innovation and growth. One of the most promising trends is the declining cost of renewable energy technologies, particularly solar photovoltaic (PV) systems. Over the past decade, the cost of solar PV modules has dropped dramatically, making solar power increasingly competitive with conventional fossil fuels. According to the International Renewable Energy Agency (IRENA, 2020), the global weighted-average cost of electricity from utility-scale solar PV fell by 82% between 2010 and 2019. This cost reduction has been driven by economies of scale, technological advancements, and increased market competition. In India, this trend has been particularly evident, with solar tariffs reaching record lows in recent years. The declining cost of solar power has enabled it to become a viable alternative to coal, which has traditionally dominated India's energy mix. This price competitiveness, coupled with India's abundant solar resources, positions solar energy as a cornerstone of the country's renewable energy strategy. As the cost of renewable technologies continues to fall, it is expected that more investment will flow into the sector, further accelerating the transition to a low-carbon economy (IRENA, 2020).

Rural Electrification and Electric Vehicles

India's renewable energy sector also offers new opportunities for growth in the areas of rural electrification and electric vehicles (EVs). Rural electrification has been a long-standing priority for the Indian government, with significant progress made in recent years. However, millions of households in remote and underserved areas still lack access to reliable electricity. Renewable energy, particularly off-grid solar solutions, provides a viable solution to this challenge, offering a means to electrify rural areas in a sustainable and cost-effective manner. The deployment of decentralized renewable energy systems, such as solar home systems and mini-grids, can help bridge the energy access gap while also reducing the reliance on diesel generators and other polluting sources of power (Das & Parikh, 2021).

Additionally, the growing demand for electric vehicles presents a significant opportunity for renewable energy integration. As India seeks to reduce its dependence on imported oil and curb urban air pollution, the government has set ambitious targets for EV adoption. The integration of renewable energy with EV charging infrastructure is critical to ensuring that the shift to electric mobility contributes to the broader goal of decarbonization. For instance, solar-powered EV charging stations can reduce the carbon footprint of EVs and provide a sustainable solution to the increased electricity demand associated with

widespread EV adoption (Das & Parikh, 2021).

International Climate Commitments

India's commitment to international climate agreements, such as the Paris Agreement, further underscores the importance of renewable energy in the country's long-term development strategy. As part of its Nationally Determined Contributions (NDCs) under the Paris Agreement, India has pledged to reduce the emissions intensity of its GDP by 33-35% by 2030, compared to 2005 levels, and to achieve 40% of its installed electricity capacity from non-fossil fuel sources by the same year (Government of India, 2021). These commitments provide a strong policy framework for the expansion of renewable energy, aligning national goals with global efforts to combat climate change.

The international community's support, in terms of both finance and technology transfer, is crucial for India to meet these targets. International collaborations can facilitate the exchange of best practices, the adoption of advanced technologies, and the mobilization of financial resources needed for large-scale renewable energy projects. Moreover, India's leadership in initiatives like the International Solar Alliance (ISA) demonstrates its commitment to global climate action and positions the country as a key player in the global transition to renewable energy (Government of India, 2021).

While India faces significant challenges in scaling up its renewable energy capacity, including financing, grid integration, and land acquisition issues, the country also has substantial opportunities to leverage its renewable energy potential. The declining costs of renewable technologies, the push for rural electrification and electric vehicles, and India's international climate commitments all provide a strong foundation for continued growth in the sector. By addressing the challenges and seizing these opportunities, India can ensure that renewable energy plays a central role in its sustainable development strategy, contributing to both economic growth and environmental sustainability.

Recommendations for Policy Enhancements

To achieve the Sustainable Development Goals (SDGs) by 2047, marking the centenary of India's independence, it is imperative that the country enhances its renewable energy policies. While India has made significant strides in increasing its renewable energy capacity, further policy improvements are necessary to ensure that these advancements are sustainable, inclusive, and capable of meeting the growing energy demands. The following recommendations provide a framework for enhancing India's renewable energy policies, which are crucial for accelerating progress towards the SDGs.

1. Strengthening Financial Mechanisms

One of the critical challenges facing India's renewable energy sector is the need for substantial investment to scale up renewable energy projects. Traditional financial models may not be sufficient to meet the required capital needs. Therefore, developing innovative financial instruments, such as green bonds and renewable energy credits, can play a pivotal role in attracting more investments into the sector. Green bonds, which are specifically earmarked for environmental projects, have already shown promise in raising capital for renewable energy projects globally. By expanding the issuance of green bonds, India can tap into a larger pool of international and domestic investors who are increasingly focused on sustainable investments (Banerjee et al., 2020). Additionally, renewable energy credits (RECs), which provide financial incentives to renewable energy producers by allowing them to sell credits on a market, can further stimulate investment by making renewable projects more economically viable. The development of these financial instruments, along with favorable tax policies and subsidies, can help bridge the investment gap in the renewable energy sector.

2. Improving Grid Infrastructure

As India continues to increase its share of renewable energy, there is a growing need to upgrade the national grid infrastructure to handle the variability and decentralization associated with renewable sources. The integration of higher shares of renewable energy, such as solar and wind, requires a grid that is both resilient and flexible. Smart grids, which use digital technology to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users, are essential in this regard. Smart grids can facilitate the integration of distributed energy resources, improve grid reliability, and reduce energy losses (Cohen et al., 2021). Furthermore, energy storage systems, such as batteries, are critical for addressing the intermittency of renewable energy sources. These systems can store excess energy generated during peak production periods and release it during periods of low production, ensuring a stable and reliable energy supply. Investing in grid modernization and energy storage technologies will be crucial for accommodating the anticipated increase in renewable energy capacity and ensuring the continuous and reliable delivery of power.

3. Promoting Decentralized Energy Systems

In India, a significant portion of the population, particularly in rural and remote areas, still lacks access to reliable electricity. Decentralized renewable energy systems offer a viable solution to this challenge by providing localized energy generation that reduces reliance on centralized grid infrastructure. These systems, which include microgrids, rooftop solar installations, and small-scale wind turbines, can enhance energy access, reduce transmission losses, and improve the overall resilience of the energy supply (Palit & Chaurey, 2020). Promoting decentralized energy systems aligns with India's broader goals of rural development and poverty alleviation by enabling communities to harness local renewable resources, thus empowering them

economically and socially. To facilitate the widespread adoption of decentralized systems, the government should implement supportive policies, such as streamlined regulatory processes, financial incentives for small-scale projects, and technical assistance programs that help communities develop and maintain these systems.

4. Fostering Innovation and R&D

The advancement of renewable energy technologies is crucial for driving the sector forward and achieving long-term sustainability. India must increase its investment in research and development (R&D) to spur innovation in advanced renewable technologies, such as next-generation solar panels, high-efficiency wind turbines, and bioenergy solutions. These innovations can significantly improve the efficiency, cost-effectiveness, and environmental impact of renewable energy systems. For instance, the development of perovskite solar cells, which promise higher efficiency at lower costs than traditional silicon-based cells, could revolutionize the solar energy industry (Ravi & Majumdar, 2021). Similarly, advancements in wind turbine technology, such as the development of larger and more efficient turbines, can increase the output of wind farms while reducing their environmental footprint. To foster innovation, the Indian government should establish dedicated R&D funds, encourage public-private partnerships, and support collaboration between research institutions and industry stakeholders. Additionally, creating an enabling environment for startups in the renewable energy sector can lead to the rapid commercialization of new technologies and the emergence of innovative business models.

5. Enhancing Policy Coordination

The success of India's renewable energy initiatives depends significantly on effective coordination between various government levels and sectors. Currently, there are instances of overlapping policies, regulatory barriers, and bureaucratic inefficiencies that can hinder the implementation of renewable energy projects. To streamline efforts and maximize the impact of renewable energy policies, it is crucial to enhance coordination between central and state governments, as well as across different sectors such as energy, environment, finance, and industry (Singh et al., 2019). A more integrated policy approach can help address inconsistencies in regulatory frameworks, ensure that resources are efficiently allocated, and foster a more coherent national strategy for renewable energy deployment. Additionally, creating intergovernmental task forces and working groups that bring together stakeholders from different sectors can facilitate better communication, reduce policy conflicts, and ensure that renewable energy initiatives are aligned with broader development goals.

As India marches towards its 2047 goals, enhancing its renewable energy policies will be essential for achieving the SDGs and ensuring sustainable development. By strengthening financial mechanisms, improving grid infrastructure, promoting decentralized energy systems, fostering innovation, and enhancing policy coordination, India can accelerate its renewable energy transition and establish itself as a global leader in sustainable energy. These policy enhancements will not only contribute to the country's energy security and environmental sustainability but also support its broader economic and social development objectives.

6. CONCLUSION

India's commitment towards renewable energy is not just a national goal or priority but it's also crucial components of global effort to combat climate change and promote sustainable development. The ambitions renewable energy policies that India has been adopted central to country's strategy to achieve its sustainable development goals (SDGs) by 2047, a milestone year that remark as (100^{th}) centaury of India as independent country. As India is world one of largest economy and most popular nations, India's every decision including energy carry significant implications not only for India's domestic growth but it's also for global environmental sustainability.

India has made substantial progress in expanding countries renewable energy capacity, and positioning and representing itself as a global leader in renewable energy sector. India installed renewable energy capacity has grown exponentially, driven by supportive of government policies, technological advancements, and international collaborations. The target to achieve 175GW of reenable energy by 2022 was a major initial target, and subsequent announcements to related to achieve 450 GW target by 2030, its reflect India's ongoing commitment and step towards clean energy. Solar energy, is in particularly has seen remarkable growth in India, with it's one of largest solar market globally (Ministry of New and Renewable Energy [MNRE], 2021). The international solar alliance, an initiative led by India, India highlights its leadership role in fostering international cooperation in renewable energy development (International Energy Agency [IEA], 2020). This progress is not just limited to capacity expansion, it also include broader socio-economic benefits. The renewable energy sector has created millions of jobs, and contributed to energy security by reducing dependency on imported fossil fuels, and improved access to of electricity in rural areas, which helps to enhanced the quality of life (living standard) of millions of peoples (IRENA, 2019). India's renewable energy initiatives has positive impact on public life-style and public health by reducing air pollution, which is a significant concern in every major cities and urban areas (World Health Organisation [WHO], 2018).

India faced several challenges to achieve the goals or Milestones of clean energy. Financial constraints, particularly the availability and affordability financing for renewable energy projects, still remains significant barrier. The high initial investment needed for renewable energy technologies and projects, coupled with risk perceived by investors, because flow of capital is limited into to this particular sector. Additionally, the integration of large-scale renewable energy into the existing

grid infrastructure poses technical challenges. The variability and intermittency of renewable energy source such as solar and wind required complicated grid management techniques, and advanced storage solutions, and a rebust transmission network to ensure quality, reliability and stability (Central Electricity Authority [CEA], 2020)

Regulatory and policy frameworks also need continuous enhancement to keep pace with the rapid developments in the renewable energy sector. While India has a comprehensive set of policies supporting renewable energy, inconsistencies at the state level, delays in project approvals, and land acquisition issues have sometimes hindered the smooth execution of renewable energy projects. Furthermore, the deployment of renewable energy must be balanced with environmental and social considerations. For instance, large-scale solar and wind farms can lead to land use conflicts, impact local biodiversity, and affect the livelihoods of communities dependent on those lands (Schwerhoff & Sy, 2017).

To overcome these challenges, strategic interventions are required. This includes policy refinements to streamline project approvals, enhance grid infrastructure, and promote innovations in energy storage and smart grid technologies. Financial mechanisms, such as green bonds, risk mitigation instruments, and public-private partnerships, should be expanded to attract more investment into the renewable energy sector (MNRE, 2021). Additionally, community engagement and stakeholder consultation processes need to be strengthened to address land use conflicts and ensure that the benefits of renewable energy projects are shared equitably.

Opportunities and the Path Forward: Looking ahead, India has the opportunity to further solidify its position as a global leader in renewable energy. Emerging technologies such as artificial intelligence (AI), blockchain, and advanced energy storage solutions offer significant potential to enhance the efficiency, reliability, and scalability of renewable energy systems (Jha et al., 2017). By integrating these technologies, India can optimize the operation of its renewable energy assets, reduce costs, and improve grid stability. Furthermore, India's renewable energy initiatives can serve as a model for other developing countries, demonstrating how sustainable development can be achieved through a combination of policy support, technological innovation, and international collaboration.

The path to 2047 will require sustained effort and vigilance. As India continues to scale up its renewable energy capacity, it must also address the associated environmental and social challenges. The success of India's renewable energy policies will not only determine the country's ability to achieve its SDGs but will also have broader implications for global efforts to combat climate change. As a major emitter of greenhouse gases, India's transition to a low-carbon economy is critical to meeting the global climate targets set out in the Paris Agreement.

Global Implications: India's success in its renewable energy transition will have far-reaching implications beyond its borders. As a leading voice in international climate negotiations, India's renewable energy achievements can inspire and influence other nations, particularly in the Global South, to adopt similar strategies. By demonstrating that economic growth and environmental sustainability are not mutually exclusive, India can help reshape the global energy landscape and contribute significantly to the global fight against climate change (IEA, 2020).

India's renewable energy policies are pivotal to its ambition of achieving sustainable development by 2047. While the journey is fraught with challenges, the opportunities for innovation, leadership, and global impact are immense. By addressing the existing challenges and capitalizing on emerging opportunities, India can set a benchmark for sustainable development, contributing not only to its own growth but also to global efforts in promoting sustainability and combating climate change.

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