



Energy Evolution: Navigating India's Conventional And Unconventional Pathways (An Insight Review)

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ARTICLE INFO ABSTRACT

In contemporary society, electricity is essential for everything from heating systems and transportation to household responsibilities and everyday activities. Electricity now plays a central part in sustainability efforts despite climate change issues because to recent technological advances like electric automobiles and heat pumps, solar assisted power grid, and many others.

Particularly, it concentrates on India's ongoing transition towards sustainable development until 2050. The respective study intends to review and examine the factors operating the rising energy demand, evaluate the functions played by traditional and alternative energy sources in meeting this demand, and critically assess the connection between enhancing energy efficiency and advancing renewable energy. It try to contribute different insightful view points on current and future prospects of the global electricity markets

This article examines critical factors that include population increase, prosperity, and technological advances, urban and industrial growth, policy environments, climate changes, geopolitical dynamics, natural disasters, and cultural changes. In light of the rising rate of worldwide warming and global crises, the article try emphasis the critical environmental features that impact the over wellbeing of sustainable society and highlights the urgent need for proactive measures to embrace new technologies, social norms, and regulatory frameworks.

Keywords: Electricity, Technological advancements, Energy demand, Renewable energy, Energy efficiency, Sustainable development, Climate change, Fossil fuels

I.INTRODUCTION

The growth of the current human civilization is greatly dependent on the availability of electricity. Electricity is used to power a wide variety of things, including the home, everyday activities, enterprises, transportation, and heating systems. It is because of technological breakthroughs such as heat pumps, solar panels, and electric automobiles that the world in which we lived has seen a substantial transformation over the course of the last several decades. There has been a remarkable rise in the quality of life in emerging economies and underdeveloped nations, such as India, China, Bangladesh, and other African countries, which has led to a considerable acceleration in the spending pattern. Energies have been propelled to the forefront of sustainability measures as a result of these developments, which have occurred at a time when the global community is struggling to solve the serious problem of climate change.

In addition to being a significant contribution to the reduction of the worldwide carbon footprint, the production of electricity is at the forefront of efforts to achieve net-zero emissions. This is because the global carbon footprint has an impact on the sustainable energy development measure for both the current generation and the generations to come. Wind and solar energy are two examples of renewable energy sources that have seen a meteoric surge in popularity, which has been one of the key driving forces behind this change. To get a comprehensive knowledge of the dynamics of this change and the consequences it will have, it is important to conduct a comprehensive study of the worldwide pattern of energy production and consumption including electricity.

The insights and overviews that are supplied by several international bodies, such as the 2023 Electricity Market Report from the International Energy Agency, provide invaluable perspectives on the shifting energy landscape and environment that is occurring in many regions of the globe. These studies provide a large

amount of information into future trends and concerns, as well as an in-depth analysis, projections, and regional perspectives that shed light on the present status of the electrical markets.

In order to understand and showcase India's energy trajectory, which identifies important driving energy indicators, possibilities, and issues created by the nation's ambitious ambitions for renewable energy, the main purpose of the debate is to understand and highlight India's energy trajectory. Because India is one of the world's leading users of energy, the country's progress towards sustainability has significant implications not just for the global energy markets but also for the environmental protection initiatives that are being undertaken.

II. REVIEW OF LITERATURE

Soomar, A. M. et al. (2022) through their research try to explore solar energy optimization strategies and the associated challenges, providing insights into the latest advancements in solar power generation technologies. Dividing technologies into photovoltaic, thermal, and hybrid categories, the research aims to guide decision-makers in solar plant construction worldwide. It commences the motion of the study by providing an overview of the research process and then explores various features, resources and techniques required for solar energy production. Each technology's economic and environmental performance is thoroughly examined, and an analysis of statistics is included to emphasize each technology's efficiency and ranks for worldwide power output. The study emphasizes how important optimization techniques are for lowering operational and investment costs, cutting emissions, and improving system dependability. It also covers a range of optimization issues that are related to the development of solar energy.

Dey, S. et al. (2022) elucidate in their study that in contrast to more traditional sources of energy like coal, petroleum and other fossil fuels renewable energy sources such as solar, wind, and water offers an unconventional and sustainable alternative that promotes energy conservation and a more environmentally sound ecosystem. It is poised at the podium position to enchant its vital existence, which is essential for sustainable development to embrace renewable energy technology due to increasing environmental issues and increased energy demand. India has become one of the biggest leading ground for growth and an investment hub for the rest of the world to provide lucrative offers in markets for renewable energy, exhibiting its commitment to environmentally sustainable projects. A number of state run programs and initiative provides an excellent base for efforts to support green energy through large-scale sustainable energy projects that emphasize the government's objective to lowering greenhouse gas emissions, reducing carbon emissions, and promoting the use of sources of clean energy. This study exhibits a unique and undermining relationship between non-conventional sources of energy production and sustainable development, highlighting key areas greenhouse gas emission levels & regional carbon footprint such, economic development and improved standard of living, and energy efficiency to encourage the optimum utilization of renewable energy. Various private and state owned initiative, proposals to increase investment in energy efficiency, renewable energy generation after generation, and technological advances highlight the potential of more improvements in the integration of renewable energy sources and protecting the environment.

Holechek, J. et al. (2022) analyzes different techniques to investigate and determine if transitioning from fossil fuels to renewable energy by 2050 is feasible. Development of renewable energy, improved energy efficiency, conservation, carbon taxes, fair energy usage, cap and trade programs, carbon capture, and nuclear power development are some of these avenues. Different conclusions derived using the data of British Petroleum statistical assessment of world energy 2021, shows that, around 83% of the global energy produced was made using fossil fuels as the main source of energy. In order to achieve zero emissions by 2050, the output of renewable energy must rise drastically, hitting between six and eight times the present levels. In order to cut global energy use by 10% or more, the study profound the importance of energy efficient measures and energy conservation techniques into the legislative actions as the key indicator to thrust the overall growth of renewable energy adoption. It also studies the significance of technological advancement, production breakthroughs in energy efficiency and putting aggressive energy conservation legislation into place. In addition, it also highlights the requirement of specific per capita energy consumption to enhance the living standard and create a pathway for lifestyle changes by 2050.

Majid, M. (2020) stated that the deployment of renewable energy in India serves multiple purposes, including advancing economic development, enhancing energy security, expanding energy access, and addressing climate change concerns. India's strong government support and favorable economic conditions have positioned it as a global leader in renewable energy markets. Various government programs and efforts in order to increase the foreign investment in manufacturing sector welcome both in domestic as well as international markets too. In the upcoming years, it is projected that the renewable energy sector will play significant role in employment generation in both developed and developing nations which provide opportunities in country like India that demonstrate summary of the successes, potential for the future, challenges, and opportunities in renewable energy economy with an emphasis on investment, employment, and the generation of power. It lists the sector's issues and makes recommendations to decision-makers, funding sources, and other interested parties on how to address them and seize opportunities for long-term prosperity.

Ahmad and Zhang's (2020) in their study to perform analysis of energy demand across developed and

developing nations, encompassing the requirements of various business sectors. It synthesizes on-demand time series, energy supply, and global trade in gas, oil, electricity, coal, and renewable energy sources. The review and analysis evaluates different aspects of energy production methods, which also includes GDP energy intensity, primary energy generation and consumption over the period of 1990 to 2040. The geographic coverage includes significant worldwide areas and economic blocs, exploring different patterns and trends in the field of energy usage. It also examines how things like socio-economic relations, economic growth and development, energy commerce, and mitigating climate change plays critical role in expansion of this energy solution forever growing energy demand. It draws attention to the many possibilities for the predicted global energy demand through 2040 and highlights the significance of policy decisions that affect the course of future energy results.

Sharma, N. K. et al. (2012) stated that Renewable energy and its growth provides solution to the energy challenges faced by energy dependent nations like India, China & Other developing nations. With adequate amount of exposure of natural, sun light in

the subcontinental region. Solar energy, in particular, provide tremendous opportunity to explore, exploit and reshape the installed energy producing capacity of the nation and give holistic support to the government objective of becoming net export of green energy enhance energy security and mitigate environmental issues.

III.OBJECTIVE

- **Analysis of Energy Demand Drivers:** Investigate the factors behind the rising energy demand, considering global and Indian contexts, including population growth, economic development, technological advancements, and policy shifts.
- **Evaluation of Energy Sources and Efficiency:** Assess the roles of both conventional and non-conventional energy sources in meeting growing demands, while exploring synergies between enhancing energy efficiency and advancing renewable energy technologies, particularly within India's sustainable development goals.
- **Examination of Non-Conventional Sources of Energy Progress in India:** Review India's strides in renewable sources of energy, analyzing its adherence to Paris Agreement INDCs, ambitious targets for renewable energy generation, investment attractiveness, and challenges faced, along with recommendations for overcoming obstacles and fostering further growth.

IV.Role of Conventional & Non-Conventional Energy Resources in Meeting Energy Demand:



Figure 1: Key Differentiator between Conventional and Non-Conventional Energy Resources [1]

The reliance on conventional sources like coal, oil, and natural gas for generating electricity has significantly put inputs in one third of the total global greenhouse gases emission.

Table 1: Global primary energy consumption estimates for 1990–2040 [2]

Region	Consumption (million tones oil equivalent)										Change (percentage per annum)		
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040	1990–2016	2016–2040
United States	1966	2119	2310	2349	2284	2273	2334	2344	2341	2325	2299	0.6%	0.0%
Brazil	126	158	188	211	268	290	330	378	419	451	477	3.4%	2.0%
EU	1672	1661	1732	1819	1754	1642	1667	1623	1570	1513	1480	- 0.1%	- 0.5%
Russia	865	662	620	647	673	674	711	720	723	722	716	- 1.0%	0.3%
Middle East	264	351	423	565	734	895	980	1065	1188	1287	1382	4.8%	1.8%
Africa	222	244	274	327	389	440	509	603	710	840	1002	2.7%	3.5%
China	483	889	1008	1800	2491	3053	3387	3753	4077	4207	4319	5.9%	1.5%
India	195	351	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%

To enhance living standards while mitigating environmental impacts, there's an urgent call for cleaner and more dependable electricity sources as shown in **Table 1**. India, spurred by its increasing energy demands spurred by economic growth initiatives, has devised the National Electricity Plan (NEP) [12] under the Ministry of Power (MoP) [12]. This comprehensive strategy spanning a decade aims to ensure widespread and cost-effective electricity access across the nation. However, with India currently ranking fourth in global carbon emissions, swift action is imperative. India's commitment to its Intended Nationally Determined Contributions (INDCs) under the Paris Agreement reflects a pivotal step towards curbing global temperature increases.

Table 2: India's anticipated primary energy usage (including renewable energy) between 2016 and 2040 [2]

	Level (Mtoe)												1990-2016	2016-2040
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040			
Total	195	251	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%	
Oil (Mb/dl)	58	75	106	122	155	212	251	308	359	419	485	5.1%	3.5%	
Gas (Bcf/dl)	11	17	24	32	54	45	57	72	89	106	128	5.6%	4.5%	
Coal	110	140	164	211	290	412	485	593	710	824	955	5.2%	3.6%	
Nuclear	1	2	4	4	5	9	11	16	27	35	44	7.1%	7.0%	
Hydro	15	17	17	22	25	29	36	43	47	50	52	2.6%	2.5%	
Renewables	0	0	1	2	7	17	41	86	133	191	256	35.1%	12.0%	

India's strong dependence on coal and costly imports of fossil fuels highlights the urgency of transitioning to other energy sources, as seen in Table 2. This is because it is expected that the global demand for power would reach its peak by the year 2030.

As a direct reaction, India is swiftly shifting its focus towards renewable energy technology in order to promote sustainable development and mitigate the consequences of climate change. Taking into account the significant part that renewable sources play in obtaining sustainable energy while simultaneously lowering emissions, India has established lofty goals for the production of renewable energy by the year 2022.

These goals include significant contributions from hydropower, solar power, wind power, and biomass combined. The promises made by a wide variety of sectors, including domestic and international businesses, are encouraging because they show that positive efforts are being made towards reaching these targets. According to projections, solar and wind energy have a significant potential in the decades to come, particularly in the subcontinental region, which is characterised by enormous geographical terrain that is abundant in natural resources. The development of jobs and the encouragement of investment in the renewable energy industry were both contributed to by a variety of government-sponsored programmes and promotional initiatives. For the purpose of maximising the growth and utilisation of non-conventional sources of energy, the financial support, proper legal framework and legislation, technical innovation, and public awareness campaign all play a key role. By eliminating the current barriers that stand in the way of the implementation of renewable energy sources and establishing rules and regulations that are compatible with one another, India has the potential to become the world's foremost leader in clean and sustainable energy.

A. Synergizing Energy Efficiency and Renewable Energy in India's Sustainable Development Journey

It has become a vital instrument for achieving balanced and sustainable energy transitions in order to lower the total global carbon footprint. This is because the production of enough energy and energy efficiency has become a key tool. In order to achieve a higher level of total energy efficiency, it is necessary for energy to be used to its fullest potential, resulting in a smaller amount of residue and a lower emission of greenhouse gases.

By increasing the efficiency and sustainability of energy systems, which would have a significant positive influence on the socioeconomic environment, the objective of this collaborative endeavour is to achieve this aim. The relevance of energy efficiency and the most cost-effective methods to optimise energy use in various regions of the globe has been recognised by a number of international organisations, including the International Energy Agency (IEA), which has acknowledged its significance and priority.

At the same time as there has been a significant increase in the demand for energy on a worldwide scale over

the course of the last twenty years, there has also been a significant decrease in the amount of carbon dioxide emissions.

According to estimations made by the International Energy Agency (IEA), increasing energy efficiency might provide financial support for forty percent of the emissions reduction objectives that were established by the Paris Agreement. In addition, the combination of energy efficiency measures and renewable energy sources not only promotes sustainable development but also makes energy uses that were previously unavailable available. A reduction in energy consumption, a decrease in CO₂ emissions, an improvement in energy security, an increase in affordability, the creation of jobs, and an expansion of access to power are some of the potential advantages that might result from doubling efficiency by the year 2030. The aims of the Paris Agreement are closely aligned with these efforts, which are of utmost importance for India due to the country's fast economic expansion and rising energy requirements.

B. Recent accomplishments in sustainable energy:

- **Renewable Power Capacity Doubled:** India has experienced a remarkable growth in its renewable power capacity over the past four years, soaring from 35,500 MW in 2013–2014 to 70,000 MW in 2017–2018.
- **Global Recognition:** India holds significant positions in the global renewable energy arena, ranking fourth in wind energy and sixth in solar energy cumulative installed capacity. As of December 2018, its overall renewable capacity ranked fifth globally.
- **Progress Towards Targets:** With the intention of reaching a cumulative renewable energy capacity of 175 GW by 2022, India has made substantial strides. By 2017–2018, it had achieved 70 GW of installed capacity, with an additional 15 GW under implementation and 25 GW tendered.
- **Surge in Solar Power:** India has witnessed a remarkable surge in solar power, experiencing an over eightfold increase in cumulative installed capacity in just four years, rising from 2.63 GW in 2013–2014 to 25.2122 GW by December 2018.
- **Renewable Electricity Generation:** In the fiscal year 2017–2018, India generated a significant amount of renewable electricity, totaling 101,839 BUs.
- **Competitive Bidding and Cost Reduction:** Through the introduction of competitive bidding guidelines for renewable power production, India has managed to significantly reduce the per-unit cost of renewable energy, ensuring transparency in the process.
- **Solar Park Development:** India boasts 41 solar parks spread across 21 states, with a combined capacity exceeding 26,144 MW. Notable projects like the Kurnool and Pavagada solar parks are indicative of the country's commitment to large-scale renewable energy initiatives.
- **Solar Power Targets:** In 2018–2019, India aimed to achieve 10 GW of ground-mounted and 1 GW of rooftop solar power capacity.
- **Expansion of Solar Park Targets:** (MNRE) [12] doubled its target for solar parks to 40 GW, signaling a push towards further encouraging extensive renewable energy projects.
- **Wind Power Expansion:** India's wind power capacity witnessed significant growth, expanding by 1.6 times in four years to reach 35.138 GW by December 2018.

C. Government Inventiveness for Renewable Energy:

Technological Advancements

- The Technology Development and Innovation Policy (TDIP) measures the following: Aiming to encourage research, development, and demonstration (RD&D) [12] in the field of renewable energy, the Technology Development and Innovation Programme (TDIP) was presented on October 6, 2017. Assessment of resources, technical advancement, and commercialization of renewable energy technologies throughout the country are the primary foci of this initiative, which has as its ultimate objective the production of renewable power devices and systems inside India. Research and development helps to support market development, efficiency advancements, cost reductions, and enhances the scalability and bankability of renewable energy sources such as wind, solar, hybrid technologies, biofuel, biogas, hydrogen fuel cells, and geothermal energies. Research and development (RD&D) provides assistance to educational institutions, corporations, and non-governmental organisations (NGOs), the purpose of which is to encourage cooperation and the sharing of information among policymakers, industry innovators, researchers, and scientists. (NISE) [12], (NIBE) [12], and (NIWE) [12] are some of the notable research and development centres that are contributing to this endeavour.
- It is a state-of-the-art programme that was initiated at the national level to stimulate research and development of new sources of renewable energies in order to minimise the dependence on traditional sources of energy. This project is called as Impacting Research Innovation and Technology (IMPRINT) [22]. Both the Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISc) are the driving forces behind this curriculum. It fosters efforts linked to fuel cells, hydrogen, biofuel, solar thermal systems, and storage for solar photovoltaic (SPV) energy. It is financed by the Ministry of New

and Renewable Energy (MNRE) [24] and the Ministry of Housing and Rural Development (MHRD) [24]. Lab policies, which were made public on December 7, 2017, also support many initiatives to achieve overall quality control and attaining international certification for worldwide acceptance. These policies were made public.

D. Financial Support Initiatives

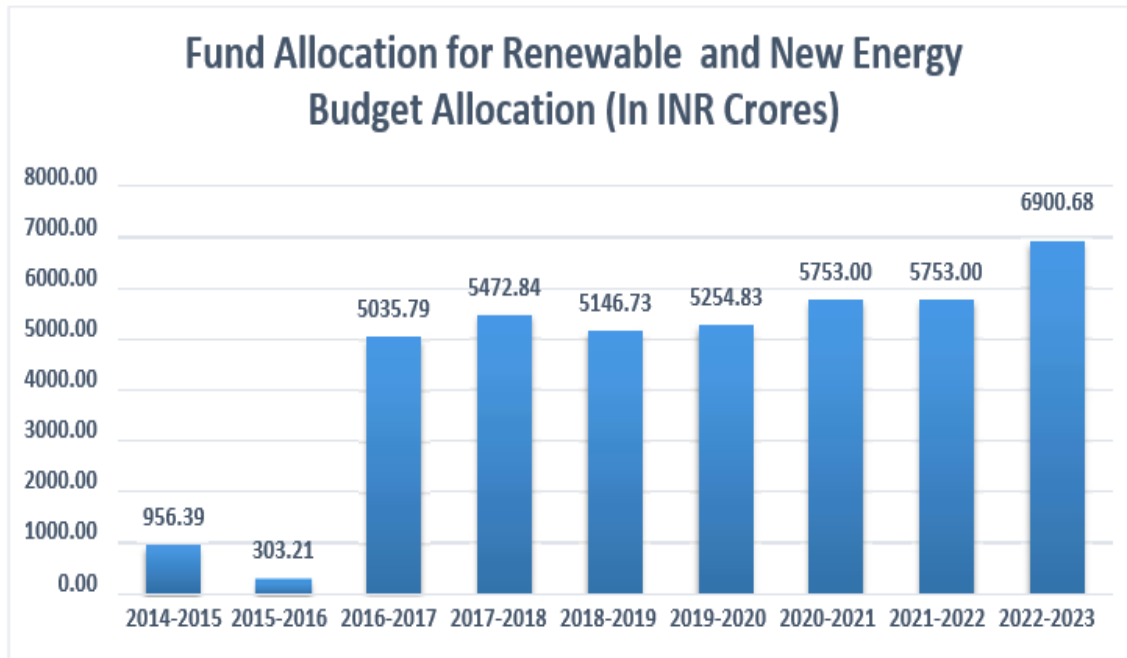


Figure 2: Allocation of Budget for Renewable and New Energy In Recent Year [13]

- MNRE offers comprehensive financial assistance, providing full support to government and NGOs, along with 50% backing to the industry, to facilitate project identification, formulation, monitoring, appraisal, approval, and financing. The budget allocation for MNRE has shown a steady increase over the years, starting from 956.39 crores in 2014- 2015 to reaching 6900.68 crores in 2022-2023.
- During the period from 2012 to 2017, MNRE disbursed 4467.8 million INR (62.52 Million USD) [12] in support, with intentions to increase the budget for technological advances in renewable energy. Financial assistance encompasses a range of activities, including R&D ventures, awareness campaigns, collaborations, training sessions, workshops, surveys, and assessment studies. MNRE encourages innovative approaches through cash rewards, extends 50% financial aid for technology validation and demonstration projects, and collaborates with industry and private entities. Furthermore, MNRE cooperates with the help of apex bank of the country to provide financial assistance in the boosting renewable energy projects under "priority sector lending" and addresses financial hurdles by imposing safeguard duties on imported solar panels and modules.

E. Policy and regulatory framework initiatives

- The government, with the aim to enhance the local strength and enhance the public to participate in the creation and adoption of renewable energy product has introduced many policies. These include setting tariffs, creating Renewable Purchase Obligations (RPOs), supporting grid connectivity, and expanding market accessibility. Various revisions to the price framework had taken place since 2018 that aimed to promote the production of energy efficient power from renewable sources. The Ministry of Power (MoP) and MNRE jointly published a long-term RPO trajectory. Issues motivated the setting up of an RPO compliance cell by the MNRE with compliance, even though State Electricity Regulatory Commissions (SERCs) were important in encouraging expansion in the renewable power sector through government regulations.
- In order to increase the mobility of non-conventional sources of energy and to optimize the adoption of energy from these sources, the government took various measures. In 2018, the wind-solar hybrid policy was introduced. Through an open bidding process, this model tries to attract different investment avenues to participate and help in increase grid stability, reduce variations in the production of renewable energy, and encourage hybridization of current plants. Despite the difficulties of installing turbines in open water, the national offshore wind energy policy, that was published in 2015, has set medium- and long-term objectives for offshore wind capacity. With a vision to create a national and international statement in the field of manufacturing & harnessing the renewable sources of energy the government of India in 2018

feed-in tariff modifications with the intention of guaranteeing competitive energy rates, drawing in investments, and promoting the manufacturing of power from an array of renewable sources, such as small hydro, solar, wind, and biomass. Additionally, the Ministry of Human Resource Development (MHRD) and the Ministry of Skill Development and Entrepreneurship (MSDE) introduced various training, skill development and educational initiative concerning renewable energy, demonstrating the government's commitment to developing a skilled labour force that may play role of catalyst in growth and development of renewable energy sector.

F. India's Global Leadership in Renewable Energy:

India with its continuous efforts in searching new horizon for creating renewable and sustainable energy resources has emerged as an important player in the global renewable energy sector, with remarkable growth in several renewable indicators and observing significant capacity expansions in recent years. India's showed remarkable potential for various local and international avenue for investments and renewable energy deployment by its position of fourth in the 2018 (RECAI) [12]. The astonishing growth of the solar industry in India is particularly important; from 4313 MW in 2016 to 9629 MW in 2017, capacity grew significantly.

G. Accelerating Renewable Energy Investment:

India in order to satisfy the ever-growing energy demand for is increasing population has made considerable investments in the renewable energy sector as a result of its improvements, which have surpassed those of most traditional energy sources. Notably, in the initial half of 2018, investments jumped by 22%, which contrasted enormously with a 15% fall in China over the same period. With continuous research and development in the renewable energy sector India is poised to surpass China as the primary growth market for renewable energy by 2020, with ambitious targets set to attain 175 GW of renewable energy capacity by 2022. Hosting the International Solar Alliance (ISA) summit in 2018 showed the nation's steadfast commitment to renewable energy and promoted global collaboration towards common goals in this area.

H. Measures to Attract Foreign Direct Investment:

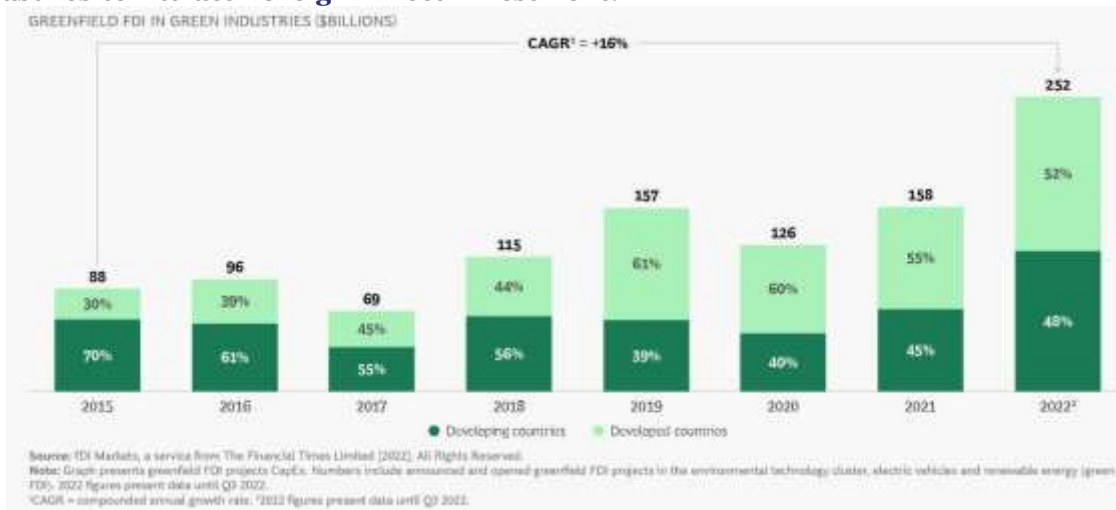


Figure 3: Green FDI in Developed Countries Since 2015 [3]

Significant efforts have been made in order to attract + Foreign Direct Investment (FDI) into India's renewable energy sector carried out by the Union Minister for New and Renewable Energy and Power. Current FDI policy streamlines the procedure for foreign investors by permitting up to 100% FDI in the industry through the automatic route. To achieve the confidence of investors and provide them assurance, the government has put in place mechanisms such as establishing a Project Development Cell and announcing the trajectory for the Renewable Purchase Obligation (RPO). Additionally, schemes like Ultra Mega Renewable Energy Parks and the Green Energy Corridor Scheme aim to enhance infrastructure, while initiatives like PM-KUSUM and the National Green Hydrogen Mission signal India's commitment to fostering innovation and facilitating renewable energy trade. With a conducive investment climate and significant FDI equity investment totaling USD 6,137.39 Million, India emerges as a key player in driving the global transition towards renewable energy.

Table 3: Targets relevant for renewable energy development [12]

Motive for power and renewable expansion and facilitating	China	India	USA

investment			
DC Purpose	By 2030, Lowering carbon emission intensity by 60% to 65% under 2005 levels, increase in the usage cleaner energy such as natural gas by 10% in primary energy mix latest by 2023, peak CO2 Emissions	A commitment to increase the adoption of non-fossil fuel in primary energy mix and reducing the usage of greenhouse gases / carbon intensity of GDP lowered by 33% to 35% under the 2005 level by 2030	To reduce the carbon emissions intensity of GDP by 83% by 2023 excluding LULUCF-land use change and forestry
NDC Implementation	The installed renewable energy capacity (including hydro energy) amounted to 493 GW in 2015 and it is planned in the thirteenth renewable energy development five year plan to achieve 680 GW by 2020	Under the National Action Plan on Climate Change (NAPCC) the recommendation has been made to increase the share of renewables power in total power generation by 15% with an intension to have the share of installed capacity of cleaner, safer and sustainable non fossil fuel to 56.5% by 2026-2027.	Respective states to reduce the carbon emission cumulatively to 32% below 2005 level by 2023 under Clean Power Plan (CPP)
Commitment towards Paris Agreement	It is estimated to accomplish its objective with its modern day policies	It is estimated to accomplish its objective with its modern day policies	US closed down Current Clean Power Plan (CPP) to increase its overall growth and now the treaty is under observation
Reliability of policy	on the higher side	on the higher side	Low
Nationwide investment Circumstances	Somewhat Medium	Relatively Very Low	Somewhat Medium
Addressing the Main Objective of Paris Agreement	Somewhat Medium	Relatively Very Low	on the higher side

V. CHALLENGES IN RENEWABLE ENERGY IMPLEMENTATION

A. Regulatory and Policy Difficulties

The renewable energy sector in India encounters obstacles due to the absence of a comprehensive regulatory framework. Conflicting policies often disrupt the developmental plans for renewable energy, leading to uncertainties within the sector.

- **State-Specific Regulatory Frameworks**

The existence of diverse regulatory frameworks across states, each with its own definition of Renewable Purchase Obligations (RPOs), heightens investment risks. Additionally, policies typically have short-term applicability, lasting only five years, which exacerbates uncertainties for investors.

- **Institutional Hurdles and Inefficient Project Approval System**

Inadequate multi-institutional collaboration and cooperation undermines progress in renewable energy. Lack of coordination between different institutions has led to delays in policy implementation, dissuading investor interest and hampering sectoral growth. With an unreliable single window project approval system causing delays and penalties for developers and making feasibility hurdles for project progress

B. Financial and Fiscal Obstacles

Providing financial assistance to the renewable projects is difficult due to its capital intensive nature, which is driven by risk, uncertainties in resource appraisal. Additionally, developers are burdened by unclear incentives and subsidies may find delayed payments from State Electricity Regulatory Commissions (SERCs).

C. Market Challenges

The consumer market is influenced by subsidies which emphasize the extensive promotion of the usage of petroleum and gases, which prevents the growth and development of renewable energy resources and products. A lack of proper channel of marketing for the cash and lending markets creates the situation even worse.

D. Technological and Environmental Hurdles

Environmental and technological concerns always play a key role for the growth and development of Renewable projects. Multifaceted risks that vary from environmental uncertainties, equipment failures,

and natural disasters, impeding sectoral expansion, inadequate infrastructural quality parameters and improper research facilities hinders the overall well-being of the sectoral growth. While the lack of testing and certification processes adds to technological challenges.

E. Awareness and Education Barriers

Holistic growth and Development of renewable energy sector is restricted by an absence of skilled labor, and lack of public awareness of renewable technology.

VI.RECOMMENDATION AND POLICY IMPROVEMENT TECHNIQUES FOR GROWTH OF RENEWABLE ENERGY IN INDIA

The Central and the state government are working hand in hand with different domestic and international organizations for ensuring the sustainability of the renewable energy sectoral growth. Different government organization such as (SERCs) [12] and the (MNRE) [12] must work collaboratively to develop an road map that is in line with to attain the national objectives in order to progress renewable energy. By utilizing different non-conventional energy resource to their maximum capacity and reducing expenses can be accomplished through establishing a "Must run status" policy and a national merit order list for renewable energy. To meet the transmission requests, more substations and lines must be built. MNRE will also be working together closely with the (PGCIL) [12] and try to increase the state funding allotted for green energy corridor projects for improvising and enhancing their future success. Various institutional setup which includes commercial banks, foreign investments, government aids are going to contribute more actively if government budget allocations are increased, GST difficulties are resolved, and renewable energy is given priority for loan availability. Stable financial management could also be obtained by necessitating their contributions from provident funds and insurance firms.

VII.CONCLUSION

Because we are the dominating power on the globe, we want to stress how urgently mankind needs to progress towards sustainable energy systems. This is particularly important in view of the serious difficulties that the world is facing and the changing climate, both of which have the potential to cause a worldwide energy crisis and to impede the growth of our species. Bringing attention to the significance of energy in the form of electricity as the primary growth indicator for any contemporary society, as well as gaining an understanding of the transition that is necessary for the global energy market and environmental initiatives that have a significant impact on the overall economic cycle, as well as the universalization of energy and its preeminent position in every economy.

The purpose of this paper is to investigate the various key indicators that lead to the world moving towards the establishment of a course of decisive action plan to address issues such as the global energy crisis and the reduction of dependence on fossil fuels. This will be accomplished by investigating the new and more sustainable driver to satisfy global energy demand, the role and functions of conventional sources of energy, alternative energy sources, and the synergies between energy efficiency and the advancement of renewable energy.

India's dedication to the adoption and production of energy products that are friendlier, safer, and more environmentally friendly in order to satisfy its day-to-day energy requirements The Intended Nationally Determined Contributions (INDCs) that are a part of the Paris Agreement highlight the fact that it has resolved the key economic and environmental issue by putting an emphasis on reducing the emission of greenhouse gases and carbon emissions and promoting sustainable energy practices.

The country has been able to position itself as a worldwide leader in renewable energy, as seen by the efforts put in by both the central government and state governments to enhance their capacity for renewable energy, particularly in the areas of solar and wind power. The nation has proved its potential on a global arena.

However, the country's lofty goal of being a net exporter of clean and green energy internationally is difficult to achieve due to a number of obstacles, including the availability of limited financial aid, the presence of complicated laws and regulations, and the presence of technical and scientific impediments. In order to overcome these challenges and overcome these barriers and in order to propel the holistic growth of renewable energy, a clearly defined route has to be established in which all stakeholders, including government agencies, regulatory bodies, and other entities, need to work together.

Some of the solutions that have been proposed to tackle these challenges include comprehensive action plans, universal legislative measures, and financial strategies that are aimed at supporting stability and innovation in the renewable energy industry. By putting these suggestions into action, India has the potential to solidify its position as a pioneer in the field of sustainable energy, make a significant contribution to the reduction of the effect on the environment, and satisfy the expanding energy requirements of nations that are fast emerging from their current state.

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