Chapter

Operational Challenges towards Deployment of Renewable Energy

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Abstract

This chapter focuses on the feasibility analysis and different challenges toward deployment of renewable energy to achieve global sustainability. The analysis emphasizes that the technological advancement, cost, and efficiency are the basic elements for mass adaptation of renewable energy. At the same time, huge available resources, favorable economies, and large social-economic benefits attract major parts of the globe toward the transition from conventional to renewable energy. The proposed chapter also indicates the major options and barriers toward the deployment of different renewable energies in India, which will act as a catalyst to achieve the India's dream renewable energy target of 175 GW by 2022. In the current era of modern technologies, highly CO_2 releasing countries like India and China demand a wide range of renewable energy integration into their power generation portfolios to meet the requirements of global sustainability. Therefore, the proposed chapter will also provide a strong base of energy security for upcoming generations.

Keywords: solar energy, wind energy, hydro power, challenges, deployment

1. Introduction

Energy is the one of the most important building blocks of human development and as such acts as the key factor in determining the economic development of all the countries. It also acts as one of the most critical components of infrastructure development, which becomes crucial for the economic growth and welfare of any nation. The existence and development of adequate infrastructure are indispensable for sustained development and growth of the economy of a country. To meet the energy demands of developing nations, the energy sector has observed rapid extension. It is important to note that the nonrenewable sources are notably consumed by human use, whereas renewable resources are produced by continuous process that can sustain indefinite human exploitation.

In the COP21 agreement, India agreed to transform its entire energy system to a zero emission-based energy system. To work on the same, the government has done a radical transformation in its green energy sector to achieve the target. In this regard, government has more focused on the exploitation of solar energy. The government of India has also launched a solar international alliance, which will help to transfer the various solar technologies with each member country [1].

Most of the renewable energy (RE) is derived directly or indirectly from the sun. Sunlight can directly be captured using solar photovoltaic cells to produce electrical energy. The Sun's heat is also driving the wind, which in turn runs the turbine to produce the energy [2]. Necessarily not all REs depend on the sun. The geo-thermal energy relies on the earth's internal heat to produce heat, while tidal energy occurs due to the moon's gravitational pull.

The nonconventional energy systems are the hot and emerging wing for world's future energy requirement and global climate change for the following two reasons:

i. RE system produces less greenhouse effect than produced by the fossil fuels.

ii. RE system provides the energy source that will not ever deplete.

The nonconventional energy is in booming phase due to the recent innovations, which has brought down the cost to a significantly low level and started to deliver on the promise of clean energy future. The environmental advantage of RE including lower carbon emission and reduced air pollution has been widely known for decades. Its numerous socioeconomic benefits, however, have only been apparent in recent decades as the development of RE technology has been more widespread.

However, RE systems are better for the environment and produce less emission than conventional energy sources [3]. But, many of these resources still face difficulties in being deployed over at large scale due to technological barriers, high initial investment, and intermittency challenges [4]. Moreover, other different obstacles have also been broadly discussed in upcoming sections.

It is important to clarify that terms "RE," "green energy," and "clean energy" are not interchangeable in all cases, for example, a "clean coal plant" is simply a coal plant with emission reduction technology. The coal plant itself is still not a "RE source." "Green energy" is a subset of RE, which boasts low or zero emissions and low environmental impacts to system as land and water [5].

RE systems are increasingly displacing dirty fossil fuels in the power sector, offering the benefits of low carbon emission and diminishing the other adverse environmental impacts. But not all sources of energy marketed as RE are beneficial to the environment. Biomass and large hydroelectric dams create difficult tradeoffs when considering the impact on wildlife, climate change, and other issues [6].

2. Types of RE sources

RE referred to as clean energy, which comes from natural sources or processes that are constantly replenished. RE is often thought of as new technology, harnessing nature's power that has long been used for heating, transportation, lighting, and so on.

2.1 Solar energy

Humans have been harnessing solar energy for thousands of years to grow crops, to stay warm, or to dry foods. According to national RE laboratory report, "More energy from the sun falls on the earth in an hour than is used by everyone in a year." Modern advance technologies offer utilization of solar energy in many ways: (a) to heat buildings, (b) to warm water, and (c) to generate power using solar photovoltaic cells made of Silicon.

Solar energy contributes roughly 3% of total electrical generation of India. But, nearly fourth of all new generating capacities came from solar in the fiscal year

Resources	Total installed capacity (MW)	2022 target (MW)
Wind	36,368	60,000
Solar	29,549	1,00,000
Biomass	9806	10,000 (biomass and waste to power)
Waste to power	138	
Small hydro	4604	5000
Total	80,467	1,75,000

Table 1.
Current installed grid interactive renewable capacity of India [13].

2018–2019. A total figure of 39,2668 GWh of solar energy has been produced in the last year using solar energy technology [7].

Solar energy systems do not produce air pollutants or greenhouse gases, and as long as they are responsibly sited, most solar panels have few environmental impacts beyond the manufacturing process.

2.2 Wind energy

Wind, which accounts for a little more than 4% of country's total electrical generation, has become the cheapest energy source in parts of the country. Top wind power states in India including Gujarat, Andhra, and Tamilnadu exploit the wind energy through various technologies like off- and on-shore technologies. The wind turbines can be placed anywhere with high wind speeds such as hilltops, open plains, or offshore in open water [7]. India has significantly increased his installed wind energy capacity and has claimed to be the fourth largest wind power producer of the world [8]. **Table 1** shows current installed capacity of wind energy in India.

2.3 Hydropower

Hydropower is the largest renewable energy source for electricity in India, which accounts for the around 11% of country's total electricity generation. Typically, hydropower relies on fast moving water in a large river or rapidly descending water from a high point and converts the force of that water into electricity by spinning a generator's turbine blades.

Large hydroelectric plants or mega dams are considered often to be a part of the RE source. Mega dams divert and reduce natural flows, restricting access for animals and human populations that rely on rivers. Small hydroelectric plants of rating less than 40 MW are less harmful for the environmental damage because it diverts only fraction of flow [9].

2.4 Biomass energy

Biomass is organic material that comes from plants and animals, which includes crops, waste wood, trees, manure, and so on for its energy resources. When biomass is burned, the chemical energy is released as heat. The produced heat can be used to generate electricity with a steam turbine. Biomass is often mistakenly described as a clean renewable fuel and a green alternative to coal and other fossil fuels because recent science shows that many forms of biomass especially from forests produce higher carbon emissions than fossil fuels [10].

2.5 Geothermal energy

The earth's core is considered to be as hot as the sun's surface, due to the slow decay of radioactive particles in rocks at the center of the planet. Drilling deep wells brings very hot underground water to the surface as a hydrothermal resource, which is then pumped through a turbine to create electricity. Geothermal plants have low emissions. There are ways to create geothermal plants where there are not underground reservoirs. But, the major barrier is the risk of earthquake in concerned areas. Somewhere, geological hot spots have been already observed [11].

2.6 Ocean energy

The ocean energy is usually deployed by four technologies: current energy technology, wave energy technology, tidal energy technology, and ocean thermal energy technology (OTET). Marine current technology is used to move the blades of the rotor of the machine to produce electricity. Wave energy technologies are generally used to convert the wave energy into electricity [12].

Tidal cycle can be observed due to the moon's gravitational force. These technologies are in their early stage of development. The drawback of the tidal energy plants appears in its initial investment because it needs to construct high civil infrastructure. Western part of India has huge potential of tidal energy in which Gulf of Kutch and Gulf of Cambay are the prime locations. Some tidal energy approaches may harm wildlife, such as tidal barrages, which work like dams and are located in an ocean bay or lagoon. Like tidal power, wave power relies on dam-like structures or ocean floor–anchored devices on or just below the water's surface. OTET utilizes ocean temperature difference to mine energy. The minimum temperature difference required for this purpose is 20°C [12].

3. RE resources with the Indian prospective

The association of mankind with energy is as historical as discovery of fire or the steam. Different battles have been fought for the energy security ever since the industrial revolution or the discovery of the scientific evolution. The nineteenth and twentieth centuries' entanglement with the oil and coal is slowly tapping feet with solar and wind or any other renewable resources for the energy. Global climate change is also one cause for the switchover from conventional energy resources to nonconventional energy resources such as solar and wind. However, the transformation or switchover would not happen disruptively as expected due to technological lack in conventional generation methods and fuels. It will require huge investments and technology transfer, and the equation is unbalanced specially when in reference with the developing nations such as India.

The rapid increase of the Indian population demands the rapid expansion of energy sector. The advancement of human life has directly affected the rate of consumption of energy. The application of advance luxury equipment in the field of transportation, agriculture, domestic application, and industries has significantly increases the demand of electricity. In order to meet the energy demand, the developing country like India is mainly dependent on fossils fuels. In recent years, India has faced many terrible conditions in terms of weather change. In such conditions, RE has been playing an important role in India's energy planning. The importance of RE sources in the transition to a sustainable energy base was recognized in the early 1970s. In the current era, RE is being used increasingly in four distinct areas: (a) power generation, (b) heating and cooling, (c) transport, and (d) rural/off-grid

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energy services. The ministry of new and renewable energy (MNRE) in India has been facilitating the renewable energy implementation of many programs including harnessing renewable power, RE for village areas for lighting, cooking and motive power, use of RE in cities for lightening, industrial and commercial applications, and so on.

RE resources account for 13.5% of the world's total energy supply and 22.5% of the world's electricity [3]. However, the power generation from renewable sources is on the rise in India, with the share of RE in the country's total installed capacity rising from 7.8% in 2008 to around 13% in 2014 [13]. **Table 1** shows the total installed capacity of RE in India till March 31, 2019. It shows that India has an installed capacity of 80.474 GW energy. Among these, wind is the largest contributor and stands at around 36.625 GW of installed capacity making India the world's fourth largest wind energy producer. Moreover, small hydropower, bioenergy, and solar energy constitute the remaining capacity of 29.55 GW.

The geographical location of India is very much favorable for generation of wind energy. Wind power capacity is mainly spread across the south, west, north, and eastern region of India. The development of wind energy system in India has started a many decade ago, when Maneklal Sankalchand Thacker, a distinguished power engineer, initiated a project with the Indian council of scientific and industrial research (CSIR) to explore the possibilities of harnessing wind power in the country. The heart of wind energy generation in India exists in the state of Tamilnadu, Gujarat, Maharashtra, Karnataka, Rajasthan, Madhya Pradesh, and Andhra Pradesh [14].

Solar energy is being realized as a one of the fastest growing clean energy sectors in India. A rapid growth of 0.522 GW of installed capacity has been observed in last 4 months. At the same time, India has the lowest per MW capital cost for the installation of the solar power plants. Looking at the geographical scenario, most part of India covers 300 clear sunny days in a year. The calculated solar energy incidence on India's land area is about 5000 trillion kilowatt-hours (kWh) per year. The available solar energy in a single year exceeds the possible energy output of all of the fossil fuel reserves in India. The daily average solar power generation capacity in India is 0.20 kWh/m^2 of used land area, which is equivalent to 1400–1800 peak rated capacity operating hours in a year with available commercially proven technology. Therefore, India has a huge opportunity for the deployment of solar energy [15].

India is the seventh largest producer of hydroelectric power in the world. As of April 30, 2017, India's installed utility-scale hydroelectric capacity was 44,594 MW, which was 13.5% of its total utility power generation capacity. This shows that hydroelectric sector has a big contribution in the total installed power generation capacity. Additionally, smaller hydroelectric power units with a total installed capacity of 4380 MW, which were 1.3% of its total utility power generation capacity, have been added in its capacity. The National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), Satluj Jal Vidyut Nigam Ltd. (SJVNL), THDC, and NTPC-Hydro are some of major public sector companies producing hydroelectric power in India. Bhakra Beas Management Board (BBMB), a state-owned enterprise in north India, has a vast potential to generate hydropower, but rivers such as Godavari, Mahanadi, Nagavali, Vamsadhara, and Narmada river basins have not been developed on a major scale due to protest from the tribal population. This shows that hydroelectric sector is highly underutilized in India [16].

The RE sector has emerged as a significant role in the country affecting the power generation capacity and in good view. This RE sector supports the government's agenda of sustainable development while becoming an integral part in meeting nation's energy demand. For recent years in past, the Government of India (GoI) has taken several initiatives such as introduction of solar parks, organizing global investor's meet, launching a massive grid connected roof top solar program for green energy corridor, and program to train 50,000 people for solar installation as Solar Mitra Scheme (SMS). Also, steps have been taken toward renewable generation obligations on new thermal and lignite plants and so on.

Apart from many obstacles of the deployment of RE resources in India, the country has the following advantages:

a. *Robust demand:* With the growing India economy, the electricity consumption is projected to reach 15,280 TWh by 2040.

b. *Increasing investments:* With GoI's ambitious targets, the sector has become attractive to various investors from foreign as well as Indian.

c. *Competitive advantage:* India is blessed with plenty of sunlight throughout the year, huge hydropower potential, various wind power generation sites, and so on.

4. Dream energy project of India

One of the reasons of increase in the demand for power in India is the growing population. Consequently, it has become necessary to explore all the possible nonconventional sources of energy to meet the issue of global climate change and to overcome the problem of energy security in the country. Energy systems around the world are witnessing toward transformations at an unprecedented rate. There has been a very rapid increase in RE technologies in last few decades. The rapid increase of energy demand forces every country to make efforts to move away from a fossil fuel-based energy generation portfolio. In this regard, India has made a remarkable dream energy project of 175 GW power generation from RE by 2022.

As depicted in **Table 1**, India has targeted an installed capacity of 175 GW by 2022. In this project, large hydropower project has not been included. If we will add the large hydropower project, the figure will rise to 225 GW, which will be a praiseworthy achievement for the country. Due to the huge feasibility of solar energy, more emphasis has been given to solar energy, which includes 100 GW of total installed capacity. It will comprise 60 GW from ground-mounted, grid-connected projects, and 40 GW from solar rooftop projects. Wind power projects will contribute 60 GW of total installed capacity. The ministry is implementing a wide range of schemes with financial support and conducive policies to achieve this target. The largest ever wind power capacity addition of 3423 MW and solar power capacity addition of 3019 MW were made in the fiscal year 2015–2016. For the first time in the year 2015–2016, the largest solar power project capacity of 20,904 MW was tendered, and 31,472 solar pumps were installed, which are higher than the total number of pumps installed during the last 24 years [17]. The installed pumps have a feature of powering through solar energy. It runs on the electricity produced through solar panel [18]. The ministry has been facilitating the implementation of broad spectrum programs for the accelerated deployment of RE. It includes the use of RE to rural and urban areas for lighting, cooking, motive power, industrial and commercial applications, and so on. To maximize the use of solar power, the ministry is making all efforts in rural and urban areas to create awareness of the benefits of solar power.

In India, the increasing addition of RE sources to its energy mix and the imminent advent of electric mobility have driven the market to look at grid-scale energy storage solutions. The grid-scale energy storage would support the sustainable growth of renewable integration and aid grid balancing efforts by increasing energy security and reliability of the nation. Most global efforts toward climate change adaptation have happened in the form of RE additions to the energy sector.

The Indian government's vision of greening the power sector will require large-scale adoption of energy storage technologies. Unfortunately, it is being met by a host of hurdles relatively high cost of technology and a lack of sector experience. The development of the energy storage sector was imminent, and unsurprisingly, the global market in 2018 was estimated at 12 GWh. This sector is very important if India is to meet its 2022 target of 175 GW. The first tender was released in 2015, and since then, the frequency of tenders with battery energy storage systems (ESS) has steadily increased, highlighting India's motivations. Several tenders for solar plants with ESS were released by the Solar Energy Corporation of India (SECI). For a grid-scale storage, cost incurred per unit energy stored is highly dependent on ramping time, efficiency, and life of storage. Technologies such as pumped-hydro, compressed air, and gravity storage are sound alternatives to battery storage [19].

Thus, it is not easy to achieve the targeted dream energy project of the country. India has to face a number of technical and nontechnical barriers for the completion of its project in the estimated time limit.

5. Challenges in the deployment of RE

The barriers or challenges can be broadly classified into two categories: (a) nontechnical challenges and (b) technical challenges. Apart from this, there also exists some other challenges toward the advancement of RE in India.

5.1 Nontechnical challenges

5.1.1 Initial investment

The investment requirement for wind and solar power-based plants is significantly higher than that of the coal-based plant. The development of a coal-based power plant requires around INR 4 crore per MW. A wind power plant with a capacity utilization of 25% requires an investment of INR 6 crore per MW. The actual investment, at more efficient capacity utilization of 80%, works out to be INR 18 crore per MW. Similarly, the investment in a solar-based plant, with a capacity utilization of 15%, is INR 18 crore. The actual investment, at 80% capacity utilization, is around INR 98 crore. Apart from this, it also requires to invest in research and development field to get new and efficient technologies for better performance.

5.1.2 Land acquisition

It is a very major issue faced by the companies or government prior to the installation of new power plant and transmission line. The factor had slowed down many RE projects in India. For example, the solar power developer company like Mercom in India faced the same problem during the expansion of its large utility scale solar initiatives. Many of the south Indian states such as Karnataka and Tamilnadu take approximately 1 year for the clearance under the act of Land (Ceiling and Regulation). Moreover, the time for the completion of such projects remains only 1.5–2 years. Similar problems arise, if any developer wants to commission a RE project near proximity to airport area. The airport authorities have divided the proximity zones in three levels: red, yellow, and green. For the yellow and green zones, companies have to certify their documents from the survey of India as well as from MNRE, which take more than 1.5 years [20].

The RE sector developer Mercom has also given in his statement in April 2019 that 1.2 GW wind project of SECI was decreased by 50% due to this reason only [20].

5.1.3 Social acceptance

Social acceptance of renewable-based energy system is still not very encouraging in urban India. Despite heavy subsidy being provided by the government for installation of solar water heaters and lighting systems, its installation is still very low. At the same time, rural part of India is facing the lack of adequate knowledge, which leads to the decrease in social acceptance of clean energy sources [21, 22].

There are six major elements of social acceptance of a RE system. These are knowledge of technology, cost, risk, perk, local situation, and decision making. Based on these factors, RE technologies are accepted and rejected in societies. For example, human manure-based biogas is highly unacceptable in the current modern Indian era. People of India treat it as dirty fuel. At the same time, social acceptance of solar energy is on the rise in all parts of India. In this regard, government has projected a target of 50,000 solar photovoltaic-based lighting system and 20,000 solar irrigation pumps for rural India. Government is also supplying 2 lakh advance solar cook stoves for rural India [23].

5.1.4 Lack of skilled manpower

The trained skilled manpower is another area, where developing countries like India need to work. Currently, the Indian RE power sector is facing severe shortage of trained personnel [21]. Due to the lack of skilled personnel, time of completion of project increases, which in turn causes cost overrun.

As per the joint report of the Council of Energy, Environment and Water (CEEW), and Natural Resource Defense Council (NRDC) of India, skilled manpower is the biggest problem for the hiring in recruits. The report also said that approximately 624,000 personnel will be either semiskilled or unskilled, which will work in industry for the completion of India's Dream RE by 2022 [24].

5.2 Technical challenges

5.2.1 Intermittent nature of renewable

The energy generation of traditional fossil-fuel plants is majorly fuel dependent in nature. Hence, consistency and predictability of amount of electricity make it more reliable than nonconventional energy-based plants. Energy provided by conventional energy plants is easily controlled by the control units. For example, energy output from a solar panels can drop without warning due to clouds. Similarly, wind speeds cannot be reliably forecasted. To prepare for this fluctuation in advance, research and investment into energy storage systems are on the rise. Moreover, wind power ramp events are also a major challenge. Therefore, developing energy storage mechanisms is essential for the efficient deployment of RE sources [22]. The grid may not always be able to absorb surplus wind power generated by the uncertain wind speed hike.

The intermittency occurs not only in energy generation but also in equipment's cost. **Table 2** shows a range of solar panel prices of different leading solar companies in India. It widely effects on the initial investment of companies [25].

Companies in India	Price range in INR/W
Adani Solar	18–35
Luminous	24–58
Vikram Solar	19–30
Microtek Solar	25–60
Waaree Solar	19–28
Tata Power Solar	20–62

Table 2.
Range of solar panel prices of different leading manufacturers in India [25].

We can easily analyze that minimum and maximum prices of solar panels are highly intermittent in nature.

5.2.2 Integration of distributed energy systems

For controlling and monitoring purpose of a renewable-based energy park, system requires intelligent tools/software for its efficient operation. But, due to the occurrence of different types of distributed energy resources in the system, it becomes very complex to monitor it during its operation. It results in the difficulty during its integration. Many RE generation sites, such as solar PV and wind farms, are distributed across a wide geographical scope. Therefore, it becomes very difficult to control and monitor without a sophisticated tools in the system. For example, the new project for offshore wind farm in India is currently under construction, which is away from coastline. For a precise and accurate energy management of the aforesaid generation sites, the data from each asset need to be combined into a singular entity [21–26]. The tool should be efficient enough to combine many items of distributed equipment into one system to provide a complete visualization of the grid.

There are many technical concerns that arise during the integration of DG into the system. The first one is the stability. When integration is done, it effects on the rotor angle of the generator. At the same time, it also effects frequency and voltage stability of the system. Hence, DGs either increase or decrease the stability of the system based on the generator rating. However, local voltage perturbation of the grid voltage can be observed due to the intermittency in the injected power from the wind and solar units [27].

The second challenge is the optimal number of placement of the DG units in the system, so that the demand reactive power will be equal to the supply reactive power, which is very important to maintain a healthy voltage level of the system [27].

The another drawback in this regard is the need of protecting devices for DG units, which increases the overall capital cost of the system [27].

5.2.3 Location dependency

Most of the RE power generations are location specific. The feasibility of wind energy system can be seen to the locations having more than the cut-off wind speed. Sometimes, generation sites and load center are far away from each other [26]. Also, transmission of power from generating station to load center produces huge cost overrun. The transmission costs become very high especially in case of offshore wind resources. Hence, these types of technology are not much feasible in land-based transmission lines.

For example, the major load center of the northern part of India lies in Delhi. But the onshore wind power plants are far away from this region. Also, the transmission of hydropower to this location causes cost overrun.

5.2.4 Lack of transmission line infrastructure

Transmission line infrastructure is also a major problem behind the expansion of RE resources in India. Although government has decided to made green energy corridor for this purpose, the biggest challenge is to guarantee that transmission systems must be ready for operation before the completion of RE projects. As the complete execution of transmission projects may take up to 5 years or even more. At the same time, the solar energy-based projects require less time. Therefore, availability of transmission infrastructure is a big problem for the rapid deployment of green energy sources.

As per the CEA, GoI report 2015, Lakshadweep island in India has its 100% energy production through RE sources. This shows a huge possibility of RE from this region, which can be utilized to the other parts of the nation. But the lack of transmission line infrastructure causes its underutilization. Similar example occurs in the states of Himachal Pradesh, Jammu Kashmir, Sikkim, Arunachal Pradesh, and Meghalaya, which have the renewable energy production of 94, 73.41, 71.08, 78.49, and 75.93%, respectively. At the same time, the states such as West Bengal, Jharkhand, and Delhi have their installed capacity of 14.43, 8.42, and 10.26%, respectively [28].

5.2.5 Mismatch in load demand centers and available corridors

There is some unsuitability in the number of load demand centers and the available corridors for RE due to the lack of an effective plan to design a dedicated infrastructure for RE transmission. For example, the 1 GW substation project at Kayathar in Tamil Nadu, India, was scheduled to be start in early 2018. Unfortunately, it could not be commissioned on time because of the independent power producers who are more inclined to transmit the power to Gujarat and Maharashtra, which have adequate load demand centers as compared to the north-eastern states.

5.2.6 Necessity of energy storage system (ESS) and associated challenges

Due to the intermittency of various REs, it is very important to integrate a ESS to get an uninterrupted power supply to the consumers. The key criteria for the choice of ESS are size, application, initial cost, and durability. The major drawback of ESS is maintenance cost, which increases the net maintenance cost of the system and increases the payback period for the system. The operation of ESS is primarily based on its charging and discharging time [27].

There are many challenges associated with the integration of ESS to a renewable integrated power supply system. Among them, most important is drawback of power electronic converter over the power quality of the system. To integrate a ESS in the system, power electronic interface unit becomes necessary. It not only increases the initial investment of the system but also decreases the power quality of the system by injecting harmonics to the system [27].

5.2.7 Other challenges

The lack of proper financial system is also a major obstacle for the expansion of RE in India. Though government provides remarkable subsidies for the solar

Year	2009–2010	2010–2011	2011–2012	2016–2017
Energy requirement (in MU)[a]	820,920	891,203	968,659	1,392,066
Share of RE as mandated under NAPCC (in %)[b]	5%	6%	7%	12%
Quantum of RE required (in MU)	41,046	53,472	67,806	167,048
RE capacity addition targeted by MNRE (in MW)[c]	15542[c]	20,376	25,211	57,000
Solar capacity targeted under JNNSM (in MW)			1000	10,000
Quantum of RE available (in MU)[d]	29,952	39,269	50,514	129,122
Additional RE required to meet RE share mandated under NAPCC (in MU)	11,094	14,203	17,292	37,926

[a] *As per 17th EPS.*
[b] *5% in 2009–2010 and 1% increase each year.*
[c] *As on 31.10.2009.*
[d] *Assuming a capacity utilization factor of 22%.*

Table 3.
Mismatch between RE capacity envisaged under different policies and capacities addition targeted 2009–2010.

PV systems, consumers are still lacking for an appreciable financial platform at the domestic level. The mega RE projects need appreciable amount of time for its completion. At the same time, the investors and stakeholders face problem due to the abrupt annulment of the RE policies by the government. Moreover, participation of private organization increases the project completion time because huge liability is not a full-recourse finance in this situation [14].

In case of development of biomass energy, obstacles occur in the process of transportation of biomass, which increases its cost of production. Also, efficiency is very low compare to conventional fossil fuel-based energy system.

The hindrance in the adaptation of new technologies based on RE sources can also be due to the lack of proper policies and regulations favoring the development of these technologies. Clear policies and legal procedures are required for the RE market to increase the interests of the investors. Additionally, standards and codes are some of the regulatory measures that enhance the adaptation of renewable energy technologies by diminishing the risk factor that comes along with investments in these projects.

Countries like India have been lacking with complete policy declaration on RE as most of the technologies are on its early advancement stage. Policies have been issues as and when necessary to facilitate the growth of specific RE technology. As per **Table 3**, targeted capacity of JNNSM is inadequate to meet the target for RE generation mandated by National Action Plan on Climate Change (NAPCC) [29].

6. Recommendations to eliminate the proposed challenges

In the previous part, different challenges have been identified and discussed, which act as a barrier toward the accomplishment of the India's dream energy project of RE. The challenges must be eradicated to stimulate global sustainable development prospective in the field of RE. Following are some recommendations to eliminate the proposed challenges:

a. Zonal grid of each state should give plots prepared by the state electricity board that hold the transmission necessities and its implementation as per load centers and available corridors, for the execution of RE-based power generation system in grid connected mode.

b. RE sector should be given priority in the rolling plan of the government, so that financial problem can be eliminated.

c. Government must frame extra budget for the research and development purpose of RE technologies, so that the nation can compete with the advance technologies.

d. There must be an attractive subsidy structure for the RE technologies at the domestic use level, so that social acceptance can be increased.

e. The necessary social awareness programs should be conducted at different parts of the country to increase the market size of the consumer for RE.

f. The problem of high initial investment can only be compensated through the advanced technologies. It is recommended to upgrade the existing technologies and adopt the superior one.

g. The use of efficient and durable energy storage system can overcome the issue of intermittent nature of RE because it will reduce the cost of maintenance, which will further decrease the operational cost of the system. At the same time, hybrid utilization along with the energy storage technology can also eliminate the problem of intermittent nature of RE.

h. The government has to promote the small-scale off-grid energy system for the rapid deployment of RE sources.

i. GoI must formulate a comprehensive policy or action plan for all-round development of the sector, encompassing all the key aspects. The action plan should be prepared in consultation with the state governments. It is understood that the energy coordination committee of GoI has approved the preparation of an umbrella RE law to provide a comprehensive legislative framework for all types of RETs, their usage, and promotion. However, GoI has fixed no timeframe for the formulation and enactment of such a law. The GoI must speed-up this task and ensure that the desired law be enacted expeditiously.

j. There is a need for stronger initiatives at local body levels for the promotion of RE. For example, local bodies must be discouraged from granting municipal approvals for commercial building in urban areas unless it houses a solar application. Solar installations should be a precondition for a power connection from the utility.

k. The commercial success of RETs depends significantly on adoption and enforcement of appropriate standards and codes. GoI must prescribe minimum performance standards in terms of durability, reliability, and performance for different RETs to ensure greater market penetration.

l. There is an urgent need for clarity on the Renewable Purchase Obligation (RPO) framework. It may be better to specify the overall RPO percentage rather than technology-specific percentages. This in turn would encourage investments in RE on the basis of technoeconomic analysis. Further, there should be no cap on RPO.

m. To meet the objective of RPO, it is imperative that an enforcement mechanism be introduced in all states.

n. RE should be declared as a priority sector. At present, the priority sector broadly comprises agriculture, small-scale industries, and other activities/borrowers (such as small business, retail trade, small transport operators, professional and self-employed persons, housing, education loans, and microcredit). The inclusion of RE in priority sectors will increase the availability of credit to this sector and lead to larger participation by commercial banks in this sector.

o. GoI should ask banks to allow an interest rebate on home loans if the owner of the house is installing a RE application such as solar water heater, solar lights, or PV panel. This would incentivize people to integrate RE technologies into their home, thereby encouraging the use of RE. The rebate could vary depending on the number of applications installed or the type of technology installed.

p. To achieve low capital costs and to capitalize on its inherent advantages in the solar sector, India needs to consider revamping and upgrading its solar R&D and manufacturing capabilities. In this regard, GoI may consider promoting a core company to produce wafer and silicon. This will enable substantial reduction in the costs of solar technologies.

q. There is an urgent need for technical assistance programs designed to increase the planning skills and understanding of RETs by utilities, regulators, local and municipal administrations, and other institutions involved.

r. Information specific to viable RETs needs to be made easily accessible. It will increase general awareness and acceptability as well as aid potential investors and sponsors of such projects.

s. Capacity building initiatives should be undertaken to train people/workers to operate and maintain RE facilities.

t. There is a need to improve the maintenance support mechanism for RE products/plants for redressing the post-installation problem faced by the users.

It can be easily suggested that the government has to mainly work in the field of financial mechanism, policy and regulation system, transmission system, social awareness programs, and technology sector to accomplish the India's dream energy project by 2022.

7. Conclusion

The chapter has been focused on to study the feasibility of different RE sectors in the Indian prospective. A analysis has been done about the government dream energy project of 175 GW by 2022. The potential of RE in India shows enormous opportunity toward its deployment, but the aforesaid technical, nontechnical, and other barriers need to be abated for the accomplishment of the project by 2022. Based on the identified obstacles, a brief recommendation has been proposed to overcome the problems. The completion of project will not only give a boost to its economy but also set a remarkable benchmark step for other nations around the globe to conquer the issue of global climate change.

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