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Renewable Energy in India: Current Status & Future

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ABSTRACT: India has been one of the champions globally in adopting renewable energy as part of its energy transition. Installed renewable energy capacity (including large hydro) rose from a few megawatts (MW) in 2010 to ~163 gigawatts (GW) as of August 2022. India's ambitious renewable energy targets and the associated policy and reform framework have been an important tailwind for the sector's development. Additionally, the transition has also resulted in shunning coal power capacity, with additions hitting rock bottom in FY2021/22. More than 606GW of coal-fired power projects have been cancelled or shelved, and 15.6GW retired in India during the 2010-2022 period.

KEYWORDS: renewable, energy, India, status, future

I. INTRODUCTION

That said, there have been several headwinds faced by the renewable energy sector lately, along with rapidly rising power demand from across the country. These factors have led to the government taking a re-look at thermal power as a fix against any power crunch in the foreseeable future. NTPC, the country's largest power producer, announced diversifying away from coal in October 2020 but recently awarded its first new coal-fired plant in about six years to meet the country's surging demand for electricity.

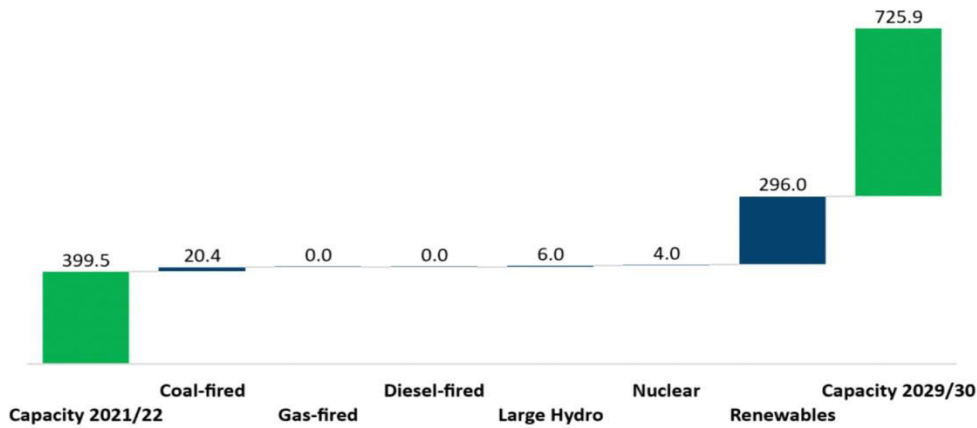
Besides having the potential to derail India's energy transition journey, a higher reliance on coal-fired power also exposes the country to the vagaries of global energy markets. Due to a shortage of domestic coal, the country has accelerated its import of the commodity. However, the Russia-Ukraine war has led to imported prices skyrocketing tenfold in the last two years, making use of imported coal expensive and widening India's current account deficit. This high coal price has also fuelled inflation in the country, with the Wholesale Price Index (WPI) crossing double digits (15%) in May/June 2022.

IEEFA and CEF forecast India's renewable energy capacity to grow rapidly with 35-40GW of new capacity additions annually through to FY2029/30, reaching 405GW.[1,2,3]

IEEFA and CEF believe that even though there is some renewed momentum building on expanding the use of domestic thermal energy, the long-term trajectory for renewable energy is still intact. IEEFA and CEF forecast India's renewable energy capacity to grow rapidly with 35-40GW of new capacity additions annually through to FY2029/30, reaching 405GW. Due to the competition from variable renewable energy sources, hyperinflation in fossil fuel commodity prices and increased global capital pledges under the US\$130 trillion Glasgow Finance Alliance for Net Zero (GFANZ) to align investments with a 1.5°C limit to global warming, we forecast that thermal power will progressively lose market share, with its generation share falling from 72.3% in FY2021/22 to just 53.4% in FY2029/30.



Figure 1: India’s Electricity Capacity Addition Forecast Until 2030 (in GW)



Source: CEA, CEF Calculations

Our projections are supported by the ambitious capacity addition targets of the Indian government and commitments by a slew of players, both state and non-state, operating across industries, such as power and oil & gas, to steel and cement through the utility and distributed renewable energy segments.

In the utility-scale segment, the combined additional capacity targets through to 2030 by some of the top players operating in the industry stand at ~231GW. This includes commitments by state-owned NTPC at 60GW, Adani Green Energy at 45GW and Tata Power, ReNew Power and Acme Solar at 25GW each. While these targets seem aggressive, the Indian government seems unbending in ensuring its targets are met through facilitating growth across the renewable energy spectrum. Financially strong investors, such as the Indian government, domestic conglomerates and some of the biggest global investors, back most industry players, lending them the financial firepower needed to fulfil their capacity addition targets.

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On the decentralised renewable energy side, several segments have the potential to grow multifold as policy-side reforms streamline current bottlenecks and demand-side drivers provide lucrative returns. Even though the country has been a laggard in rooftop solar, state-level reforms, corporate decarbonisation, and net-zero pledges from commercial and industrial (C&I) customers will accelerate this segment exponentially. Similarly, solar pumps have a target of 30.8GW under the KUSUM scheme. But, the scheme has not made much headway to date due to several bottlenecks. With more than 20 million grid-connected agricultural pumps in India, consuming over 17% of the nation’s total electricity, the opportunity for solar pumps is enormous.

Several Indian public sector undertakings (PSUs) have also been committing to install renewable energy capacity in a bid to decarbonise their operations, diversify their business portfolio and also contribute to the government’s renewables plans. Non-power sector PSUs, including Oil and Natural Gas Corporation (ONGC), Indian Oil Corporation (IOC), Bharat Petroleum Corporation Limited (BPCL) and GAIL, have a combined renewable capacity addition target of 16.5GW by 2030.

On the demand side, green hydrogen is a major force that promises to massively drive India’s clean energy ambitions. India’s green hydrogen target of 5 million tonnes per annum (MTPA) by 2030 will require an additional renewable energy capacity of ~118GW. Corporates, such as the Adani Group and Reliance Industries, have wholeheartedly supported the country’s green hydrogen policy, announced in June 2022, and its 5MTPA target, with several major commitments.

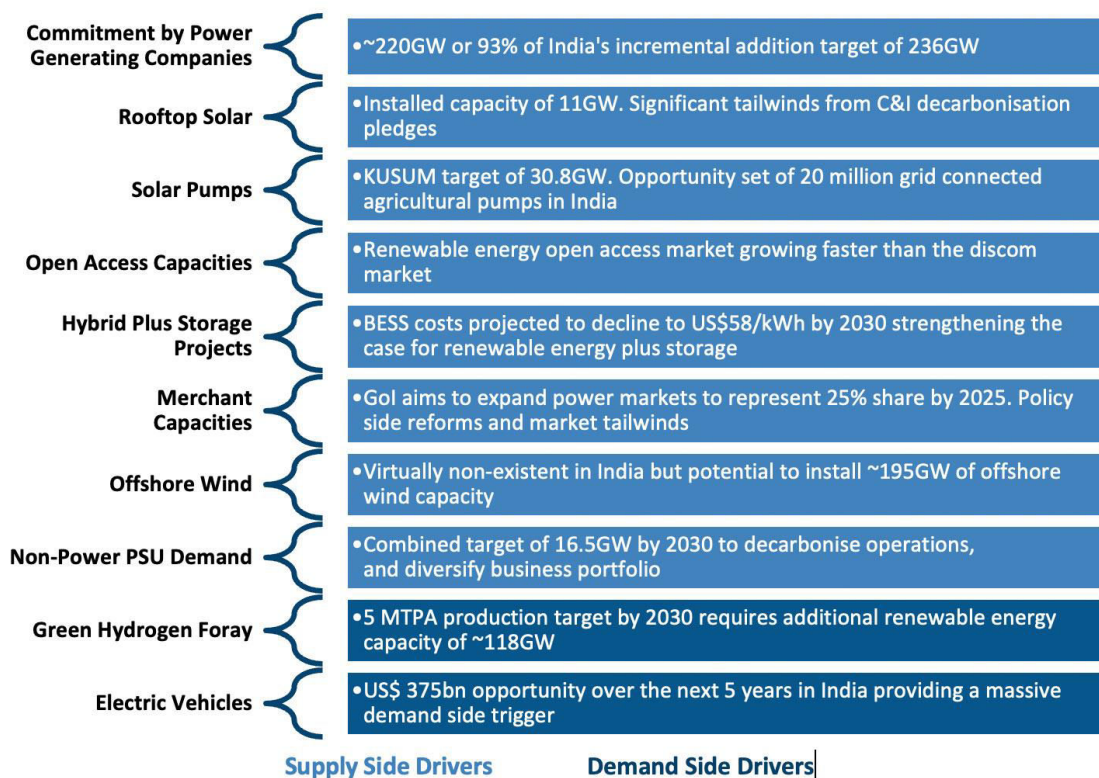
Several other upside triggers are also present, which can contribute to the country’s clean energy target.

- Open access capacity installations buoyed by higher demand from C&I customers for procuring clean energy.
- Future wind-solar hybrid projects integrated with storage assets will become more competitive than thermal power, with the cost of battery energy storage systems (BESS) projected to keep falling.



- Merchant capacities traded through power exchanges are also projected to grow exponentially. Policy-side reforms and favourable market dynamics will continue to act as a driver for green merchant capacity additions in the foreseeable future.
- Offshore wind, a non-starter in the Indian markets, has been given a new lease of life through recent government reforms and targets. With a coastline of about 7,600 km, offering the potential to install ~195GW of offshore wind capacity, the segment can contribute to India’s clean energy target.
- Lastly, electric vehicle uptake, projected to be a multi-billion-dollar opportunity in the country, will be a major demand-side driver for clean electricity generation assets.

Figure 2: Demand and Supply Side Drivers of Renewable Energy Capacity Addition in India



Source: IEEFA & CEF Analysis

Understanding the clean energy commitments of domestic players compared with global counterparts also provides perspective on where India’s renewable energy plans stand relative to international developments and what Indian utility players can leverage from the experience of global leaders. An analysis of the clean energy trajectory and plans of four global energy transition utility leaders: NextEra Energy (US), RWE (Germany), Ørsted (Denmark) and Enel (Italy), shows that they are betting heavily on the global energy transition opportunities. Across all the jurisdictions where they operate, a recurrent theme has been accelerating action to progressively reduce fossil fuel-based asset reliance and doubling down efforts in supporting the clean energy sector.

These four majors have accelerated their world-leading investment plans in response to the hyperinflation of fossil fuel commodity prices, reflective of the increasing cost competitiveness of firmed renewable energy (even in the absence of a CO2 price). Further, all four have clearly articulated ambitious decarbonisation targets, and it is noteworthy that none rely on carbon offsets or the mythical use of carbon capture and storage (CCS). All are tapping into the global green bond market for long-duration funding at very commercial rates.

NextEra Energy’s investment plan to deploy US\$85-95 billion over four years through to 2025 across solar, wind and storage assets supports its core strategy of expansion in the renewable energy segment. The recently announced



Inflation Reduction Act of 2022 in the U.S. will likely accelerate its plans. The company has laid out a detailed decarbonisation target, announcing a Real Zero to eliminate all scope 1 and scope 2 carbon emissions across its operations by 2045. Clearly articulated interim decarbonisation targets set on a five-yearly basis will massively support NextEra's ability to tap global sustainable finance markets, a point that Indian utilities, such as NTPC and Tata Power, should note. The company's green pivot has struck a chord with investors too, with its share price materially outperforming the US equity market (+199%) over the last decade.

RWE of Germany has similar ambitions. The company targets to double to a net 50GW of renewable energy capacity by 2030, which requires a €50 billion (US\$50 billion) investment. The German government coalition's objective to accelerate the expansion of renewable energy as a top priority buoys RWE's plans. RWE has doubled down on battery storage too, with a target of 3GW by 2030 up from just 47MW as of December 2021, underpinning the role that storage will play in the transition globally. Another integral part of RWE's strategy is green hydrogen. It targets building 2GW of in-house electrolysis capacity by 2030 across Germany, the U.K. and Netherlands. Similar to NextEra, RWE has also pledged to decarbonise its operations to become climate-neutral by 2040, helping it issue two green bonds totalling €2 billion (US\$2 billion) in May 2022.[4,5,6]

RWE's share market performance is a study in itself for Indian utilities pivoting towards clean energy. Its shares saw significant underperformance in the first half of the last decade as the fossil fuel heavy utility underestimated the speed of the stranding of thermal power assets, combined with the entirely flawed spin-off of its renewable energy division (Innogy) in 2015/16. But since then, RWE has pivoted to embrace a planned energy transition, and the company's shares have materially outperformed the German equity market.

Another European player, Ørsted, is the perfect model of a conventional utility transitioning to clean energy and, in the process, creating immense wealth for its shareholders. The company currently has 7.5GW of offshore wind in operation and another 14.5GW of awarded capacity under development. It has a global target of installing 30GW of offshore wind capacity by 2030. After championing offshore wind technology in Europe, Ørsted is now exploring other markets, such as Taiwan, the U.S. and Spain, using its technological know-how and experience to capitalise on government reforms and market tailwinds to fulfil its 2030 capacity targets. This is a credit to its early pivot to clean energy compared to regional peers. Green hydrogen finds an important place in the company's future strategy. Denmark's green hydrogen foray into deep decarbonisation of transport and shipping sectors, along with developments across the Netherlands and Germany, have provided market signals to Ørsted to develop expertise in this nascent technology too. Lastly, Italy's Enel, with a global portfolio of 55.4GW of renewable energy, including 28GW of hydro, spanning 27 countries, is the world's largest renewable energy company. Enel's gross capex budget for 2021-2030 is a staggering €210 billion (US\$210 billion), split between grid modernisation and expansions and renewable energy generation capacity. As of June 2022, Enel had a gross project pipeline of over 400GW of renewables capacity, including 64GW of batteries. This is by far the largest investment program of any company globally in decarbonisation. While betting massively on battery storage, the company has not made many inroads into green hydrogen. On the sustainability front, Enel brought forward its target for Net Zero by a decade to 2040 by driving electrification and ongoing accelerated phase-out of its end-of-life thermal capacity with firmed renewable energy capacity. Unlike most fossil fuel firms, this puts no reliance on carbon removal and is 100% aligned and certified with 1.5°C in accordance with the SBTi. As a leading investor in decarbonisation, Enel has regularly tapped the global sustainable bond markets, being a leader in the issuance of sustainability-linked instruments.



Figure 3: Clean Energy Commitments and Decarbonisation Efforts of Global Utilities

COMPANY	GREEN ENERGY COMMITMENTS	DECARBONISATION EFFORTS
NEXTERA ENERGY	Plan to deploy US\$85-95 billion in renewable energy by 2025, adding 8-11GW of new wind, 14-19GW of solar and 5-7GW of energy storage	Real Zero emissions target no later than 2045. Clearly articulated interim decarbonisation targets
RWE	Plans to invest €50 billion (US\$50 billion) this decade in phasing out the existing coal-fired fleet and investing in new renewable energy. Battery storage target of 3GW and green hydrogen target of 2GW electrolysis capacity by 2030	Targets being climate-neutral by 2040. Targets confirmed by SBTi and in line with the Paris Agreement
ØRSTED	Global target of installing 30GW of offshore and 17.5GW of onshore wind capacity by 2030 across Europe, Taiwan, the US, and Spain, among others	Frontrunner in sustainability-related disclosures globally. 2040 net zero target confirmed by SBTi
ENEL	Capex budget for 2021-2030 of €210 billion (US\$210 billion) across grids modernisation and expansion of renewable energy. Gross project pipeline of over 400GW of renewables capacity, including 64GW of batteries	Brought forward its target for Net Zero by a decade to 2040 by driving electrification and phase-out of thermal capacity

Source: Company Reports; IEEFA & CEF Analysis

II. DISCUSSION

India stands 4th globally in Renewable Energy Installed Capacity (including Large Hydro), 4th in Wind Power capacity & 5th in Solar Power capacity (as per REN21 Renewables 2023 Global Status Report). The country has set an enhanced target at the COP26 of 500 GW of non-fossil fuel-based energy by 2030. This has been a key pledge under the Panchamrit. This is the world's largest expansion plan in renewable energy.

India's installed non-fossil fuel capacity has increased 396% in the last 8.5 years and stands at more than 203.19 GW (including large Hydro and nuclear), about 45.5% of the country's total capacity (as of Jun 2023). India saw the highest year-on-year growth in renewable energy additions of 9.83% in 2022. The installed solar energy capacity has increased by 30 times in the last 9 years and stands at 85.47 GW as of Jun 2023. India's solar energy potential is estimated to be 748 GWp as estimated by National Institute of Solar Energy (NISE). The installed Renewable energy capacity (including large hydro) has increased by around 128% since 2014.

Up to 100% FDI is allowed under the automatic route for renewable energy generation and distribution projects subject to provisions of The Electricity Act 2003.

Renewable energy sources have a combined installed capacity of 150+ GW.

As of May 2023, Renewable energy sources, including large hydropower, have a combined installed capacity of 195.01 GW.

The following is the installed capacity for Renewables:

Wind power: 46.65 GW

Solar Power: 85.47 GW

Biomass/Co-generation: 10.35 GW

Small Hydro Power: 5 GW[7,8,9]

Waste To Energy: 0.59 GW

Large Hydro: 46.92 GW

India has set a target to reduce the carbon intensity of the nation's economy by less than 45% by the end of the decade, achieve 50 percent cumulative electric power installed by 2030 from renewables, and achieve net-zero carbon emissions by 2070. India aims for 500 GW of renewable energy installed capacity by 2030.



India aims to produce 5 Mn Tonnes of green hydrogen by 2030. This will be supported by 125 GW of renewable energy capacity.

50 solar parks with an aggregate capacity of 37.49 GW have been approved in India. Wind Energy has an off-shore target of 30 GW by 2030, with potential sites identified.

Following list of activities in renewable energy will be considered for trading carbon credits under bilateral/cooperative approaches under Article 6.2 mechanism as assigned under the National Designated Authority for the Implementation of the Paris Agreement (NDAIAPA):

Renewable energy with storage (only stored component)

Solar thermal power

Off-shore wind

Green Hydrogen

Tidal energy, Ocean Thermal Energy, Ocean Salt Gradient Energy, Ocean Wave Energy and Ocean Current Energy

High Voltage Direct Current Transmission in conjunction with the renewable energy projects

Green Ammonia

Union Budget 2023 Highlights

Green Growth identified is one of the nodes in the SAPTARISHI (7 priorities).

\$2.4 Bn National Hydrogen Mission for production of 5 MMT by 2030, \$36 Mn additional in Budget.

4 GWh Battery Energy Storage Systems supported through Viability Gap Funding

Pumped Storage Projects has received a push with a detailed framework to be formulated.

\$1.02/2.5 Bn Central Sector Support for ISTS infrastructure for 13 GW Renewable Energy from Ladakh

III. RESULTS

The Union Cabinet chaired by the Prime Minister, Shri Narendra Modi has given its approval to introduce the Production-Linked Incentive (PLI) Scheme in High Efficiency Solar PV Modules for Enhancing India's Manufacturing Capabilities and Enhancing Exports – Aatmanirbhar Bharat. 1. The national programme on 'high-efficiency solar PV modules': Tranche 1: INR 4500 Cr (\$550 Mn) Tranche 2: INR 19,500 Cr (\$2.37 Bn). The second phase, launched on 21st Sept 2022, is expected to build 65 GW of annual manufacturing capacity. 2. National Green Hydrogen Mission with an outlay of INR 19,744 Cr (\$2.4 Bn) targets 5 MMT annual green hydrogen/ ammonia production by 2030. Investors can place their bids till 7th September 2023 to seek incentives. The scheme focuses on Direct employment of about 30,000 and Indirect employment of about 1,20,000 persons; Import substitution of around INR 17,500 Cr every year, and Impetus to Research & Development to achieve higher efficiency in solar PV modules.

The sources of electricity production such as coal, oil, and natural gas have contributed to one-third of global greenhouse gas emissions. It is essential to raise the standard of living by providing cleaner and more reliable electricity [1]. India has an increasing energy demand to fulfill the economic development plans that are being implemented. The provision of increasing quanta of energy is a vital pre-requisite for the economic growth of a country [2]. The National Electricity Plan [NEP] [3] framed by the Ministry of Power (MoP) has developed a 10-year detailed action plan with the objective to provide electricity across the country, and has prepared a further plan to ensure that power is supplied to the citizens efficiently and at a reasonable cost. According to the World Resource Institute Report 2017 [4, 5], India is responsible for nearly 6.65% of total global carbon emissions, ranked fourth next to China (26.83%), the USA (14.36%), and the EU (9.66%). Climate change might also change the ecological balance in the world. Intended Nationally Determined Contributions (INDCs) have been submitted to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. The latter has hoped to achieve the goal of limiting the rise in global temperature to well below 2 °C [6, 7]. According to a World Energy Council [8] prediction, global electricity demand will peak in 2030. India is one of the largest coal consumers in the world and imports costly fossil fuel [8]. Close to 74% of the energy demand is supplied by coal and oil. According to a report from the Center for monitoring Indian economy, the country imported 171 million tons of coal in 2013–2014, 215 million tons in 2014–2015, 207 million tons in 2015–2016, 195 million tons in 2016–2017, and 213 million tons in 2017–2018 [9]. Therefore, there is an urgent need to find alternate sources for generating electricity.

In this way, the country will have a rapid and global transition to renewable energy technologies to achieve sustainable growth and avoid catastrophic climate change. Renewable energy sources play a vital role in securing sustainable energy with lower emissions [10]. It is already accepted that renewable energy technologies might significantly cover the electricity demand and reduce emissions. [10,11,12] In recent years, the country has developed a sustainable path for its energy supply. Awareness of saving energy has been promoted among citizens to increase the use of solar, wind, biomass, waste, and hydropower energies. It is evident that clean energy is less harmful and often cheaper. India is aiming to attain 175 GW of renewable energy which would consist of 100 GW from solar energy, 10 GW from bio-power, 60 GW from wind power, and 5 GW from small hydropower plants by the year 2022 [11]. Investors have promised to achieve more than 270 GW, which is significantly above the ambitious targets. The promises are as follows: 58 GW by foreign companies, 191 GW by private companies, 18 GW by private sectors, and 5 GW by the Indian Railways [12]. Recent estimates show that in 2047, solar potential will be more than 750 GW and wind potential will be 410 GW [13, 14]. To reach the ambitious targets of generating 175 GW of renewable energy by 2022, it is essential that the government creates 330,000 new jobs and livelihood opportunities [15, 16].

A mixture of push policies and pull mechanisms, accompanied by particular strategies should promote the development of renewable energy technologies. Advancement in technology, proper regulatory policies [17], tax deduction, and attempts in efficiency enhancement due to research and development (R&D) [18] are some of the pathways to conservation of energy and environment that should guarantee that renewable resource bases are used in a cost-effective and quick manner. Hence, strategies to promote investment opportunities in the renewable energy sector along with jobs for the unskilled workers, technicians, and contractors are discussed. This article also manifests technological and financial initiatives [19], policy and regulatory framework, as well as training and educational initiatives [20, 21] launched by the government for the growth and development of renewable energy sources. The development of renewable technology has encountered explicit obstacles, and thus, there is a need to discuss these barriers. Additionally, it is also vital to discover possible solutions to overcome these barriers, and hence, proper recommendations have been suggested for the steady growth of renewable power [22,23,24]. Given the enormous potential of renewables in the country, coherent policy measures and an investor-friendly administration might be the key drivers for India to become a global leader in clean and green energy.

Projection of global primary energy consumption

An energy source is a necessary element of socio-economic development. The increasing economic growth of developing nations in the last decades has caused an accelerated increase in energy consumption. This trend is anticipated to grow [25]. A prediction of future power consumption is essential for the investigation of adequate environmental and economic policies [26]. Likewise, an outlook to future power consumption helps to determine future investments in renewable energy. Energy supply and security have not only increased the essential issues for the development of human society but also for their global political and economic patterns [27]. Hence, international comparisons are helpful to identify past, present, and future power consumption.

The size and growth of a country's population significantly affects the demand for energy. With 1.368 billion citizens, India is ranked second, of the most populous countries as of January 2019 [31]. The yearly growth rate is 1.18% and represents almost 17.74% of the world's population. The country is expected to have more than 1.383 billion, 1.512 billion, 1.605 billion, 1.658 billion people by the end of 2020, 2030, 2040, and 2050, respectively. Each year, India adds a higher number of people to the world than any other nation and the specific population of some of the states in India is equal to the population of many countries.[13,14,15]

The growth of India's energy consumption will be the fastest among all significant economies by 2040, with coal meeting most of this demand followed by renewable energy. Renewables became the second most significant source of domestic power production, overtaking gas and then oil, by 2020. The demand for renewables in India will have a tremendous growth of 256 Mtoe in 2040 from 17 Mtoe in 2016, with an annual increase of 12%

IV. CONCLUSION

The MNRE has been taking dedicated measures for improving the renewable sector, and its efforts have been satisfactory in recognizing various obstacles.

Policy and regulatory obstacles

- A comprehensive policy statement (regulatory framework) is not available in the renewable sector. When there is a requirement to promote the growth of particular renewable energy technologies, policies might be declared that do not match with the plans for the development of renewable energy.
- The regulatory framework and procedures are different for every state because they define the respective RPOs (Renewable Purchase Obligations) and this creates a higher risk of investments in this sector. Additionally, the policies are applicable for just 5 years, and the generated risk for investments in this sector is apparent. The biomass sector does not have an established framework.
- Incentive accelerated depreciation (AD) is provided to wind developers and is evident in developing India's wind-producing capacity. Wind projects installed more than 10 years ago show that they are not optimally maintained. Many owners of the asset have built with little motivation for tax benefits only. The policy framework does not require the maintenance of the wind projects after the tax advantages have been claimed. There is no control over the equipment suppliers because they undertake all wind power plant development activities such as commissioning, operation, and maintenance. Suppliers make the buyers pay a premium and increase the equipment cost, which brings burden to the buyer.
- Furthermore, ready-made projects are sold to buyers. The buyers are susceptible to this trap to save income tax. Foreign investors hesitate to invest because they are exempted from the income tax.
- Every state has different regulatory policy and framework definitions of an RPO. The RPO percentage specified in the regulatory framework for various renewable sources is not precise.
- RPO allows the SERCs and certain private firms to procure only a part of their power demands from renewable sources.
- RPO is not imposed on open access (OA) and captive consumers in all states except three.
- RPO targets and obligations are not clear, and the RPO compliance cell has just started on 22.05.2018 to collect the monthly reports on compliance and deal with non-compliance issues with appropriate authorities.
- Penalty mechanisms are not specified and only two states in India (Maharashtra and Rajasthan) have some form of penalty mechanisms.
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- The parameter to determine the tariff is not transparent in the regulatory framework and many SRECs have established a tariff for limited periods. The FiT is valid for only 5 years, and this affects the bankability of the project.
- Many SERCs have not decided on adopting the CERC tariff that is mentioned in CERCs regulations that deal with terms and conditions for tariff determinations. The SERCs have considered the plant load factor (PLF) because it varies across regions and locations as well as particular technology. The current framework does not fit to these issues.
- Third party sale (TPS) is not allowed because renewable generators are not allowed to sell power to commercial consumers. They have to sell only to industrial consumers. The industrial consumers have a low tariff and commercial consumers have a high tariff, and SRCS do not allow OA. This stops the profit for the developers and investors.
- Institutional obstacles
- Institutes, agencies stakeholders who work under the conditions of the MNRE show poor inter-institutional coordination. The progress in renewable energy development is limited by this lack of cooperation, coordination, and delays. The delay in implementing policies due to poor coordination, decrease the interest of investors to invest in this sector.
- The single window project approval and clearance system is not very useful and not stable because it delays the receiving of clearances for the projects ends in the levy of a penalty on the project developer.
- Pre-feasibility reports prepared by concerned states have some deficiency, and this may affect the small developers, i.e., the local developers, who are willing to execute renewable projects.
- The workforce in institutes, agencies, and ministries is not sufficient in numbers.

- Proper or well-established research centers are not available for the development of renewable infrastructure.
- Customer care centers to guide developers regarding renewable projects are not available.[16,17,18]
- Standards and quality control orders have been issued recently in 2018 and 2019 only, and there are insufficient institutions and laboratories to give standards/certification and validate the quality and suitability of using renewable technology.
- Financial and fiscal obstacles
- There are a few budgetary constraints such as fund allocation, and budgets that are not released on time to fulfill the requirement of developing the renewable sector.
- The initial unit capital costs of renewable projects are very high compared to fossil fuels, and this leads to financing challenges and initial burden.
- There are uncertainties related to the assessment of resources, lack of technology awareness, and high-risk perceptions which lead to financial barriers for the developers.
- The subsidies and incentives are not transparent, and the ministry might reconsider subsidies for renewable energy because there was a sharp fall in tariffs in 2018.
- Power purchase agreements (PPA) signed between the power purchaser and power generators on pre-determined fixed tariffs are higher than the current bids (Economic survey 2017–2018 and union budget on the 01.02.2019). For example, solar power tariff dropped to 2.44 INR (0.04 USD) per unit in May 2017, wind power INR 3.46 per unit in February 2017, and 2.64 INR per unit in October 2017.
- Investors feel that there is a risk in the renewable sector as this sector has lower gross returns even though these returns are relatively high within the market standards.
- There are not many developers who are interested in renewable projects. While newly established developers (small and local developers) do not have much of an institutional track record or financial input, which are needed to develop the project (high capital cost). Even moneylenders consider it risky and are not ready to provide funding. Moneylenders look exclusively for contractors who have much experience in construction, well-established suppliers with proven equipment and operators who have more experience.
- If the performance of renewable projects, which show low-performance, faces financial obstacles, they risk the lack of funding of renewable projects.
- Financial institutions such as government banks or private banks do not have much understanding or expertise in renewable energy projects, and this imposes financial barriers to the projects.
- Delay in payment by the SERCs to the developers imposes debt burden on the small and local developers because moneylenders always work with credit enhancement mechanisms or guarantee bonds signed between moneylenders and the developers.
- Market obstacles
- Subsidies are adequately provided to conventional fossil fuels, sending the wrong impression that power from conventional fuels is of a higher priority than that from renewables (unfair structure of subsidies)
- There are four renewable markets in India, the government market (providing budgetary support to projects and purchase the output of the project), the government-driven market (provide budgetary support or fiscal incentives to promote renewable energy), the loan market (taking loan to finance renewable based applications), and the cash market (buying renewable-based applications to meet personal energy needs by individuals). There is an inadequacy in promoting the loan market and cash market in India.
- The biomass market is facing a demand-supply gap which results in a continuous and dramatic increase in biomass prices because the biomass supply is unreliable (and, as there is no organized market for fuel), and the price fluctuations are very high. The type of biomass is not the same in all the states of India, and therefore demand and price elasticity is high for biomass.
- Renewable power was calculated based on cost-plus methods (adding direct material cost, direct labor cost, and product overhead cost). This does not include environmental cost and shields the ecological benefits of clean and green energy.
- There is an inadequate evacuation infrastructure and insufficient integration of the grid, which affects the renewable projects. SERCs are not able to use all generated power to meet the needs because of the non-availability of a proper evacuation infrastructure. This has an impact on the project, and the SERCs are forced to buy expensive power from neighbor states to fulfill needs.
- Extending transmission lines is not possible/not economical for small size projects, and the seasonality of generation from such projects affect the market.
- There are few limitations in overall transmission plans, distribution CapEx plans, and distribution licenses for renewable power. Power evacuation infrastructure for renewable energy is not included in the plans.

- Even though there is an increase in capacity for the commercially deployed renewable energy technology, there is no decline in capital cost. This cost of power also remains high. The capital cost quoted by the developers and providers of equipment is too high due to exports of machinery, inadequate built up capacity, and cartelization of equipment suppliers (suppliers join together to control prices and limit competition).
- There is no adequate supply of land, for wind, solar, and solar thermal power plants, which lead to poor capacity addition in many states.
- Technological obstacles
- Every installation of a renewable project contributes to complex risk challenges from environmental uncertainties, natural disasters, planning, equipment failure, and profit loss.
- MNRE issued the standardization of renewable energy projects policy on the 11th of December 2017 (testing, standardization, and certification). They are still at an elementary level as compared to international practices. Quality assurance processes are still under starting conditions. Each success in renewable energy is based on concrete action plans for standards, testing and certification of performance.
- The quality and reliability of manufactured components, imported equipment, and subsystems is essential, and hence quality infrastructure should be established. There is no clear document related to testing laboratories, referral institutes, review mechanism, inspection, and monitoring.
- There are not many R&D centers for renewables. Methods to reduce the subsidies and invest in R&D lagging; manufacturing facilities are just replicating the already available technologies. The country is dependent on international suppliers for equipment and technology. Spare parts are not manufactured locally and hence they are scarce.
- Awareness, education, and training obstacles
- There is an unavailability of appropriately skilled human resources in the renewable energy sector. Furthermore, it faces an acute workforce shortage.
- After installation of renewable project/applications by the suppliers, there is no proper follow-up or assistance for the workers in the project to perform maintenance. Likewise, there are not enough trained and skilled persons for demonstrating, training, operation, and maintenance of the plant.
- There is inadequate knowledge in renewables, and no awareness programs are available to the general public. The lack of awareness about the technologies is a significant obstacle in acquiring vast land for constructing the renewable plant. Moreover, people using agriculture lands are not prepared to give their land to construct power plants because most Indians cultivate plants.
- The renewable sector depends on the climate, and this varying climate also imposes less popularity of renewables among the people.
- The per capita income is low, and the people consider that the cost of renewables might be high and they might not be able to use renewables.
- The storage system increases the cost of renewables, and people believe it too costly and are not ready to use them.
- The environmental benefits of renewable technologies are not clearly understood by the people and negative perceptions are making renewable technologies less prevalent among them.
- Environmental obstacles
- A single wind turbine does not occupy much space, but many turbines are placed five to ten rotor diameters from each other, and this occupies more area, which include roads and transmission lines.
- In the field of offshore wind, the turbines and blades are bigger than onshore wind turbines, and they require a substantial amount of space. Offshore installations affect ocean activities (fishing, sand extraction, gravel extraction, oil extraction, gas extraction, aquaculture, and navigation). Furthermore, they affect fish and other marine wildlife.
- Wind turbines influence wildlife (birds and bats) because of the collisions with them and due to air pressure changes caused by wind turbines and habitat disruption. Making wind turbines motionless during times of low wind can protect birds and bats but is not practiced.
- Sound (aerodynamic, mechanical) and visual impacts are associated with wind turbines. There is poor practice by the wind turbine developers regarding public concerns. Furthermore, there are imperfections in surfaces and sound—absorbent material which decrease the noise from turbines. The shadow flicker effect is not taken as severe environmental impact by the developers.
- Sometimes wind turbine material production, transportation of materials, on-site construction, assembling, operation, maintenance, dismantlement, and decommissioning may be associated with global warming, and there is a lag in this consideration.
- Large utility-scale solar plants require vast lands that increase the risk of land degradation and loss of habitat.

- The PV cell manufacturing process includes hazardous chemicals such as 1-1-1 Trichloroethene, HCL, H₂SO₄, N₂, NF, and acetone. Workers face risks resulting from inhaling silicon dust. The manufacturing wastes are not disposed of properly. Proper precautions during usage of thin-film PV cells, which contain cadmium—telluride, gallium arsenide, and copper-indium-gallium-diselenide are missing. These materials create severe public health threats and environmental threats.
- Hydroelectric power turbine blades kill aquatic ecosystems (fish and other organisms). Moreover, algae and other aquatic weeds are not controlled through manual harvesting or by introducing fish that can eat these plants.
- Discussion and recommendations based on the research
- Policy and regulation advancements
- The MNRE should provide a comprehensive action plan or policy for the promotion of the renewable sector in its regulatory framework for renewables energy. The action plan can be prepared in consultation with SERCs of the country within a fixed timeframe and execution of the policy/action plan.
- The central and state government should include a “Must run status” in their policy and follow it strictly to make use of renewable power.
- A national merit order list for renewable electricity generation will reduce power cost for the consumers. Such a merit order list will help in ranking sources of renewable energy in an ascending order of price and will provide power at a lower cost to each distribution company (DISCOM). The MNRE should include that principle in its framework and ensure that SERCs includes it in their regulatory framework as well.
- SERCs might be allowed to remove policies and regulatory uncertainty surrounding renewable energy. SERCs might be allowed to identify the thrust areas of their renewable energy development.
- There should be strong initiatives from municipality (local level) approvals for renewable energy-based projects.
- Higher market penetration is conceivable only if their suitable codes and standards are adopted and implemented. MNRE should guide minimum performance standards, which incorporate reliability, durability, and performance.
- A well-established renewable energy certificates (REC) policy might contribute to an efficient funding mechanism for renewable energy projects. It is necessary for the government to look at developing the REC ecosystem.
- The regulatory administration around the RPO needs to be upgraded with a more efficient “carrot and stick” mechanism for obligated entities. A regulatory mechanism that both remunerations compliance and penalizes for non-compliance may likely produce better results.
- RECs in India should only be traded on exchange. Over-the-counter (OTC) or off-exchange trading will potentially allow greater participation in the market. A REC forward curve will provide further price determination to the market participants.
- The policymakers should look at developing and building the REC market.
- Most states have defined RPO targets. Still, due to the absence of implemented RPO regulations and the inadequacy of penalties when obligations are not satisfied, several of the state DISCOMs are not complying completely with their RPO targets. It is necessary that all states adhere to the RPO targets set by respective SERCs.
- The government should address the issues such as DISCOM financials, must-run status, problems of transmission and evacuation, on-time payments and payment guarantees, and deemed generation benefits.
- Proper incentives should be devised to support utilities to obtain power over and above the RPO mandated by the SERC.
- The tariff orders/FiTs must be consistent and not restricted for a few years.
- Transmission requirements
- The developers are worried that transmission facilities are not keeping pace with the power generation. Bays at the nearest substations are occupied, and transmission lines are already carrying their full capacity. This is due to the lack of coordination between MNRE and the Power Grid Corporation of India (PGCIL) and CEA. Solar Corporation of India (SECI) is holding auctions for both wind and solar projects without making sure that enough evacuation facilities are available. There is an urgent need to make evacuation plans.
- The solution is to develop numerous substations and transmission lines, but the process will take considerably longer time than the currently under-construction projects take to get finished.
- In 2017–2018, transmission lines were installed under the green energy corridor project by the PGCIL, with 1900 circuit km targeted in 2018–2019. The implementation of the green energy corridor project explicitly meant to connect renewable energy plants to the national grid. The budget allocation of INR 6 billion for 2018–2019 should be increased to higher values.
- The mismatch between MNRE and PGCIL, which are responsible for inter-state transmission, should be rectified.



- State transmission units (STUs) are responsible for the transmission inside the states, and their fund requirements to cover the evacuation and transmission infrastructure for renewable energy should be fulfilled. Moreover, STUs should be penalized if they fail to fulfill their responsibilities.
- The coordination and consultation between the developers (the nodal agency responsible for the development of renewable energy) and STUs should be healthy.
- Financing the renewable sector
- The government should provide enough budget for the clean energy sector. China's annual budget for renewables is 128 times higher than India's. In 2017, China spent USD 126.6 billion (INR 9 lakh crore) compared to India's USD 10.9 billion (INR 75500 crore). In 2018, budget allocations for grid interactive wind and solar have increased but it is not sufficient to meet the renewable target.
- The government should concentrate on R&D and provide a surplus fund for R&D. In 2017, the budget allotted was an INR 445 crore, which was reduced to an INR 272.85 crore in 2016. In 2017–2018, the initial allocation was an INR 144 crore that was reduced to an INR 81 crore during the revised estimates. Even the reduced amounts could not be fully used, there is an urgent demand for regular monitoring of R&D and the budget allocation.
- The Goods and Service Tax (GST) that was introduced in 2017 worsened the industry performance and has led to an increase in costs and poses a threat to the viability of the ongoing projects, ultimately hampering the target achievement. These GST issues need to be addressed.
- Including the renewable sector as a priority sector would increase the availability of credit and lead to a more substantial participation by commercial banks.
- Mandating the provident funds and insurance companies to invest the fixed percentage of their portfolio into the renewable energy sector.
- Banks should allow an interest rebate on housing loans if the owner is installing renewable applications such as solar lights, solar water heaters, and PV panels in his house. This will encourage people to use renewable energy. Furthermore, income tax rebates also can be given to individuals if they are implementing renewable energy applications.
- Improvement in manufacturing/technology
- The country should move to domestic manufacturing. It imports 90% of its solar cell and module requirements from Malaysia, China, and Taiwan, so it is essential to build a robust domestic manufacturing basis.
- India will provide “safeguard duty” for merely 2 years, and this is not adequate to build a strong manufacturing basis that can compete with the global market. Moreover, safeguard duty would work only if India had a larger existing domestic manufacturing base.
- The government should reconsider the safeguard duty. Many foreign companies desiring to set up joint ventures in India provide only a lukewarm response because the given order in its current form presents inadequate safeguards.
- There are incremental developments in technology at regular periods, which need capital, and the country should discover a way to handle these factors.
- To make use of the vast estimated renewable potential in India, the R&D capability should be upgraded to solve critical problems in the clean energy sector.
- A comprehensive policy for manufacturing should be established. This would support capital cost reduction and be marketed on a global scale.
- The country should initiate an industry-academia partnership, which might promote innovative R&D and support leading-edge clean power solutions to protect the globe for future generations.
- Encourage the transfer of ideas between industry, academia, and policymakers from around the world to develop accelerated adoption of renewable power.
- Awareness about renewables
- Social recognition of renewable energy is still not very promising in urban India. Awareness is the crucial factor for the uniform and broad use of renewable energy. Information about renewable technology and their environmental benefits should reach society.
- The government should regularly organize awareness programs throughout the country, especially in villages and remote locations such as the islands.
- The government should open more educational/research organizations, which will help in spreading knowledge of renewable technology in society.
- People should regularly be trained with regard to new techniques that would be beneficial for the community.
- Sufficient agencies should be available to sell renewable products and serve for technical support during installation and maintenance.

- Development of the capabilities of unskilled and semiskilled workers and policy interventions are required related to employment opportunities.
- An increase in the number of qualified/trained personnel might immediately support the process of installations of renewables.
- Renewable energy employers prefer to train employees they recruit because they understand that education institutes fail to give the needed and appropriate skills. The training institutes should rectify this issue. Severe trained human resources shortages should be eliminated.
- Upgrading the ability of the existing workforce and training of new professionals is essential to achieve the renewable goal.
- Hybrid utilization of renewables
- The country should focus on hybrid power projects for an effective use of transmission infrastructure and land.
- India should consider battery storage in hybrid projects, which support optimizing the production and the power at competitive prices as well as a decrease of variability.
- Formulate mandatory standards and regulations for hybrid systems, which are lagging in the newly announced policies (wind-solar hybrid policy on 14.05.2018).
- The hybridization of two or more renewable systems along with the conventional power source battery storage can increase the performance of renewable technologies.
- Issues related to sizing and storage capacity should be considered because they are key to the economic viability of the system.
- Fiscal and financial incentives available for hybrid projects should be increased.[19,20]

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