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GREEN ENERGY STRATEGIES FOR SUSTAINABLE DEVELOPMENT

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Introduction

1. 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 . 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. The National Electricity Plan [NEP] 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 , 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 . According to a World Energy Council prediction, global electricity demand will peak in 2030. India is one of the largest coal consumers in the world and imports costly fossil fuel . 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 . Therefore, there is an urgent need to find alternate sources for generating electricity.

2. 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. It is already accepted that renewable energy technologies might significantly cover the electricity demand and reduce emissions. 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 . 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. Recent estimates show that in 2047, solar potential will be more than 750 GW and wind potential will be 410 GW. 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.

3. 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, tax deduction, and attempts in efficiency enhancement due to research and development (R&D) 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, policy and

regulatory framework, as well as training and educational initiatives 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. 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

4. 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. A prediction of future power consumption is essential for the investigation of adequate environmental and economic policies. 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. Hence, international comparisons are helpful to identify past, present, and future power consumption. In 2016, India's overall energy consumption was 724 million tons of oil equivalent (Mtoe) and is expected to rise to 1921 Mtoe by 2040 with an average growth rate of 4.2% per annum. Energy consumption of various major countries comprises commercially traded fuels and modern renewables used to produce power. In 2016, India was the fourth largest energy consumer in the world after China, the USA, and the Organization for economic co-operation and development (OECD) in Europe. The projected estimation of global energy consumption demonstrates that energy consumption in India is continuously increasing and retains its position even in 2035/2040. The increase in India's energy consumption will push the country's share of global energy demand to 11% by 2040 from 5% in 2016. Emerging economies such as China, India, or Brazil have experienced a process of rapid industrialization, have increased their share in the global economy, and are exporting

enormous volumes of manufactured products to developed countries. This shift of economic activities among nations has also had consequences concerning the country's energy use.

Projected Primary Energy Consumption in India

5. 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. 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. 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%. The primary energy consumption of renewables for the BRIC countries (Brazil, Russia, India, and China) from 2016 to 2040. India consumed around 17 Mtoe of renewable energy in 2016, and this will be 256 Mtoe in 2040. It is probable that India's energy consumption will grow fastest among all major economies by 2040, with coal contributing most in meeting this demand followed by renewables. The percentage share of renewable consumption in 2016 was 2% and is predicted to increase by 13% by 2040.

How Renewable Energy Sources Contribute to the Energy Demand in India

6. Even though India has achieved a fast and remarkable economic growth, energy is still scarce. Strong economic growth in India is escalating the demand for energy, and more energy sources are required to cover this demand. At the same time, due to the increasing population and environmental deterioration, the country faces the challenge of sustainable development. The gap between demand and supply of power is expected to rise in the future. In 2018, the energy demand was 1,212,134 GWh, and the availability was 1,203,567 GWh,

i.e., a deficit of −0.7%. According to the Load generation and Balance Report (2016–2017) of the Central Electricity Authority of India (CEA), the electrical energy demand for 2021–2022 is anticipated to be at least 1915 terawatt hours (TWh), with a peak electric demand of 298 GW. Increasing urbanization and rising income levels are responsible for an increased demand for electrical appliances, i.e., an increased demand for electricity in the residential sector. The increased demand in materials for buildings, transportation, capital goods, and infrastructure is driving the industrial demand for electricity. An increased mechanization and the shift to groundwater irrigation across the country is pushing the pumping and tractor demand in the agriculture sector, and hence the large diesel and electricity demand. The penetration of electric vehicles and the fuel switch to electric and induction cook stoves will drive the electricity demand in the other sectors. According to the International Renewable Energy Agency (IRENA), a quarter of India's energy demand can be met with renewable energy. The country could potentially increase its share of renewable power generation to over one-third by 2030. The estimated contribution of renewable energy sources to the total energy demand. MoP along with CEA in its draft national electricity plan for 2016 anticipated that with 175 GW of installed capacity of renewable power by 2022, the expected electricity generation would be 327 billion units (BUs), which would contribute to 1611 BU energy requirements. This indicates that 20.3% of the energy requirements would be fulfilled by renewable energy by 2022 and 24.2% by 2027. Figure 1 shows the ambitious new target for the share of renewable energy in India's electricity consumption set by MoP. As per the order of revised RPO (Renewable Purchase Obligations, legal act of June 2018), the country has a target of a 21% share of renewable energy in its total electricity consumption by March 2022. In 2014, the same goal was at 15% and increased to 21% by 2018. It is India's goal to reach 40% renewable sources by 2030.

Estimated Renewable Energy Potential in India

7. The estimated potential of wind power in the country during 1995 was found to be 20,000 MW (20 GW), solar energy was 5 × 1015 kWh/pa, bioenergy was 17,000 MW, bagasse cogeneration was 8000 MW, and small hydropower was 10,000 MW. For 2006, the

renewable potential was estimated as 85,000 MW with wind 4500 MW, solar 35 MW, biomass/bioenergy 25,000 MW, and small hydropower of 15,000 MW. According to the annual report of the Ministry of New and Renewable Energy (MNRE) for 2017–2018, the estimated potential of wind power was 302.251 GW (at 100-m mast height), of small hydropower 19.749 GW, biomass power 17.536 GW, bagasse cogeneration 5 GW, waste to energy (WTE) 2.554 GW, and solar 748.990 GW. The estimated total renewable potential amounted to 1096.080 GW assuming 3% wasteland, which is shown in Table 7. India is a tropical country and receives significant radiation, and hence the solar potential is very high.

Gross Electricity Generation From Renewable Energy in India

8. The overall generation (including the generation from grid-connected renewable sources) in the country has grown exponentially. Between 2014–2015 and 2015–2016, it achieved 1110.458 BU and 1173.603 BU, respectively. The same was recorded with 1241.689 BU and 1306.614 BU during 2015–2016 and 1306.614 BU from 2016–2017 and 2017–2018, respectively. Figure 3 indicates that the annual renewable power production increased faster than the conventional power production. The rise accounted for 6.47% in 2015–2016 and 24.88% in 2017–2018, respectively. Remarkably, the energy generation from conventional sources reached 811.143 BU and from renewable sources 9.860 BU in 2010 compared to 1.206.306 BU and 88.945 BU in 2017, respectively. It is observed that the price of electricity production using renewable technologies is higher than that for conventional generation technologies, but is likely to fall with increasing experience in the techniques involved. It is observed that the highest renewable energy generation was achieved from Karnataka (16.57%), Tamilnadu (15.82%), Andhra Pradesh (11.92%), and Gujarat (10.87%) as per November 2018. While adding four years from 2015–2016 to 2018–2019 Tamilnadu [50] remains in the first position followed by Karnataka, Maharashtra, Gujarat and Andhra Pradesh.

It can be concluded that the wind-based energy generation as per 2017–2018 is most prominent with 51.71%, followed by solar energy (25.40%), Bagasse (11.63%), small hydropower (7.55%), biomass (3.34%), and WTE (0.35%). There has been a constant

increase in the generation of all renewable sources from 2014–2015 to date. Wind energy, as always, was the highest contributor to the total renewable power production. The percentage of solar energy produced in the overall renewable power production comes next to wind and is typically reduced during the monsoon months. The definite improvement in wind energy production can be associated with a "good" monsoon. Cyclonic action during these months also facilitates high-speed winds. Monsoon winds play a significant part in the uptick in wind power production, especially in the southern states of the country. An estimation of gross electricity generation from renewable energy based on the 2015 report of the National Institution for Transforming India (NITI Aayog). It is predicted that the share of renewable power will be 10.2% by 2022, but renewable power technologies contributed a record of 13.4% to the cumulative power production in India as of the 31st of August 2018. The power ministry report shows that India generated 122.10 TWh and out of the total electricity produced, renewables generated 16.30 TWh as on the 31st of August 2018. According to the India Brand Equity Foundation report, it is anticipated that by the year 2040, around 49% of total electricity will be produced using renewable energy.

Current Achievements in Renewable Energy 2016–2017

India cares for the planet and has taken a groundbreaking journey in renewable energy through the last 4 years. A dedicated ministry along with financial and technical institutions have helped India in the promotion of renewable energy and diversification of its energy mix. The country is engaged in expanding the use of clean energy sources and has already undertaken several large-scale sustainable energy projects to ensure a massive growth of green energy.

1. India doubled its renewable power capacity in the last 4 years. The cumulative renewable power capacity in 2013–2014 reached 35,500 MW and rose to 70,000 MW in 2017–2018.
2. India stands in the fourth and sixth position regarding the cumulative installed capacity in the wind and solar sector, respectively. Furthermore, its cumulative installed renewable capacity stands in fifth position globally as of the 31st of December 2018.

3. As said above, the cumulative renewable energy capacity target for 2022 is given as 175 GW. For 2017–2018, the cumulative installed capacity amounted to 70 GW, the capacity under implementation is 15 GW and the tendered capacity was 25 GW. The target, the installed capacity, the capacity under implementation, and the tendered capacity.

4. There is tremendous growth in solar power. The cumulative installed solar capacity increased by more than eight times in the last 4 years from 2.630 GW (2013–2014) to 22 GW (2017–2018). As of the 31st of December 2018, the installed capacity amounted to 25.2122 GW.

5. The renewable electricity generated in 2017–2018 was 101839 BUs.

6. The country published competitive bidding guidelines for the production of renewable power. It also discovered the lowest tariff and transparent bidding method and resulted in a notable decrease in per unit cost of renewable energy.

7. In 21 states, there are 41 solar parks with a cumulative capacity of more than 26,144 MW that have already been approved by the MNRE. The Kurnool solar park was set up with 1000 MW; and with 2000 MW the largest solar park of Pavagada (Karnataka) is currently under installation.

8. The target for solar power (ground mounted) for 2018–2019 is given as 10 GW, and solar power (Rooftop) as 1 GW.

9. MNRE doubled the target for solar parks (projects of 500 MW or more) from 20 to 40 GW.

10. The cumulative installed capacity of wind power increased by 1.6 times in the last 4 years. In 2013–2014, it amounted to 21 GW, from 2017 to 2018 it amounted to 34 GW, and as of 31st of December 2018, it reached 35.138 GW. This shows that achievements were completed in wind power use.

11. An offshore wind policy was announced. Thirty-four companies (most significant global and domestic wind power players) competed in the "expression of interest" (EoI) floated on the plan to set up India's first mega offshore wind farm with a capacity of 1 GW.

12. 682 MW small hydropower projects were installed during the last 4 years along with 600 watermills (mechanical applications) and 132 projects still under development.

13. MNRE is implementing green energy corridors to expand the transmission system. 9400 km of green energy corridors are completed or under implementation. The cost spent on it was INR 10141 crore (101,410 Million INR = 1425.01 USD). Furthermore, the total capacity of 19,000 MVA substations is now planned to be complete by March 2020.

14. MNRE is setting up solar pumps (off-grid application), where 90% of pumps have been set up as of today and between 2014–2015 and 2017–2018. Solar street lights were more than doubled. Solar home lighting systems have been improved by around 1.5 times. More than 2,575,000 solar lamps have been distributed to students. The details are illustrated in Fig. 5.

15. From 2014–2015 to 2017–2018, more than 2.5 lakh (0.25 million) biogas plants were set up for cooking in rural homes to enable families by providing them access to clean fuel.

16. New policy initiatives revised the tariff policy mandating purchase and generation obligations (RPO and RGO). Four wind and solar inter-state transmission were waived; charges were planned, the RPO trajectory for 2022 and renewable energy policy was finalized.

17. Expressions of interest (EoI) were invited for installing solar photovoltaic manufacturing capacities associated with the guaranteed off-take of 20 GW. EoI indicated 10 GW floating solar energy plants.

18. Policy for the solar-wind hybrid was announced. Tender for setting up 2 GW solar-wind hybrid systems in existing projects was invited.

19. To facilitate R&D in renewable power technology, a National lab policy on testing, standardization, and certification was announced by the MNRE.

20. The Surya Mitra program was conducted to train college graduates in the installation, commissioning, operations, and management of solar panels. The International Solar Alliance (ISA) headquarters in India (Gurgaon) will be a new commencement for solar energy improvement in India.

21. The renewable sector has become considerably more attractive for foreign and domestic investors, and the country expects to attract up to USD 80 billion in the next 4 years from 2018–2019 to 2021–2022.

22. The solar power capacity expanded by more than eight times from 2.63 GW in 2013–2014 to 22 GW in 2017–2018.

23. A bidding for 115 GW renewable energy projects up to March 2020 was announced.

Conclusion

The renewable sector suffers notable obstacles. Some of them are inherent in every renewable technology; others are the outcome of a skewed regulative structure and marketplace. The absence of comprehensive policies and regulation frameworks prevent the adoption of renewable technologies. The renewable energy market requires explicit policies and legal procedures to enhance the attention of investors. There is a delay in the authorization of private sector projects because of a lack of clear policies. The country should take measures to attract private investors. Inadequate technology and the absence of infrastructure required to establish renewable technologies should be overcome by R&D. The government should allow more funds to support research and innovation activities in this sector. There are insufficiently competent personnel to train, demonstrate, maintain, and operate renewable energy structures and therefore, the institutions should be proactive in preparing the workforce. Imported equipment is costly compared to that of locally manufactured; therefore, generation of renewable energy becomes expensive and even unaffordable. Hence, to decrease the cost of renewable products, the country should become involve in the manufacturing of renewable products. Another significant infrastructural obstacle to the development of renewable energy technologies is unreliable connectivity to the grid. As a consequence, many investors lose their faith in renewable energy technologies and are not ready to invest in them for fear of failing. India should work on transmission and evacuation plans.

Inadequate servicing and maintenance of facilities and low reliability in technology decreases customer trust in some renewable energy technologies and hence prevent their selection.

Adequate skills to repair/service the spare parts/equipment are required to avoid equipment failures that halt the supply of energy. Awareness of renewable energy among communities should be fostered, and a significant focus on their socio-cultural practices should be considered. Governments should support investments in the expansion of renewable energy to speed up the commercialization of such technologies. The Indian government should declare a well-established fiscal assistance plan, such as the provision of credit, deduction on loans, and tariffs. The government should improve regulations making obligations under power purchase agreements (PPAs) statutorily binding to guarantee that all power DISCOMs have PPAs to cover a hundred percent of their RPO obligation. To accomplish a reliable system, it is strongly suggested that renewables must be used in a hybrid configuration of two or more resources along with conventional source and storage devices. Regulatory authorities should formulate the necessary standards and regulations for hybrid systems. Making investments economically possible with effective policies and tax incentives will result in social benefits above and beyond the economic advantages.

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