

Renewable Distributed Generation and its Impact in Rural India

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Abstract— Despite many sincere attempts from the authorities to increase the quality of power supplied to the rural households of India, a large population of rural India is still remains power-deprived. To change this situation, renewable energy along with distributed generation can become a feasible solution. In this paper, an in-depth analysis of the potential of renewable distributed generation is presented to tackle this power crisis. It also takes into account the government initiatives taken so far and the challenges lying ahead in this field.

Keywords—Renewable, Distributed Generation, Grid, Utility, Supply

I. INTRODUCTION

The amount of energy consumed by the people of a country directly indicates its living standard. In India, the energy consumption is not uniform across the country. The urban population has access to all day electricity whereas there are still millions of Indians living in far remote areas in darkness. Distributed generation has become an area of extensive research worldwide. By definition it means a system where the power generating facilities are not concentrated at specific sites rather they are distributed over the entire network; in most cases nearer to the load points reducing the transmission and distribution losses. The power system network in India is mostly traditional. Most of the power generation facilities are the bulk generators like thermal, hydro and nuclear power plants. After independence, continuous efforts are being made to make each and every household of the country accessible by the traditional grid. While increasing in generation, transmission and distribution facilities are going on we also need to focus on the fact that in a vast country with 1.2 billion of population, these traditional sources are not sufficient to achieve 100% electrification. The thermal and nuclear power plants pollutes the atmosphere with large amount of toxic gases and poses a threat to the environment. It is high time we divert our attention to small scale, sustainable solutions. Distributed generation gives us a chance to provide power to those who are still inaccessible by the traditional grid, or may be suffering through the problem of inadequate supply by utilizing renewable energy resources which are available near the load points. Distributed generation has great potential in developing countries like India. As per the statistical data provided by the Government of India, the

energy consumption will rise to a whopping 1894.7 Twh by the year 2022. The government has targeted to achieve a renewable installed capacity of 175 GW by the FY2022. Utilizing renewable resources like solar, wind, micro-hydro, bio-fuel cell etc. we can gradually make a shift towards these green sources of energy and hopefully these will solve the problem of power crisis to a great extent. Although the process sounds pretty simple, in reality it involves a lot of complexities. Due to this reason, renewable distributed generation has emerged as a trending topic power system research recently.

II. POTENTIAL BENEFITS OF DISTRIBUTED GENERATION IN INDIA

According to the 2011 census of India, 68.84% of India's total population reside on the villages. The total number of villages is given as 6,40,867. These villages can be classified into two categories; first one consisting of those villages which are already reached by the national grid and the second where the grid is not able to reach. In both these category of villages, people are still deprived of sufficient amount of electricity. Some villages are at such remote locations that taking up transmission line up to them is nearly impossible. People in the villages are suffering from the crisis of load curtailment, poor power quality, theft of power etc. Considering all these issues, distributed generation comes with a lot of promises if implemented in an efficient manner. Distributed generation (DG) has mostly renewable resources lying near to the load points. They can alone supply the load or may have the facility of interconnection with the main grid. This brings sustainability, flexibility and reliability to the system. India's current solar power installed

capacity is 3 GW which is less than 0.5% of the estimated potential. Solar power has penetrated many Indian villages but mostly as an independent system with no connection to the main grid. It lacks the benefits of grid integration. To sustain these DG initiatives in the long run, they should be made investor friendly, there has to be benefit of both the supplier and customer. In spite of its so many advantages, some issues have appeared to be bottleneck in successfully implementing DG in rural India which need to be addressed soon to extract its benefits completely.

III. GOVERNMENT INITIATIVES TAKEN

Before independence, the concept of India as a nation had not flourished. There was not any umbrella organization to look after the prospects of electrification. The British government was not very keen to take electrification as a mission. Whatever they did was only to serve their colonial interest. During British rule, generation, supply and utilization of electricity was a local affair. There was no concept of a grid. For example, a single diesel generator used to generate and distribute power within a limited area. Before independence, the power sector has private participation, but after independence, in 1948, electricity was enforced as concurrent subject between state and the central government. It has been listed at serial number 38 of the 52 concurrent subjects mentioned in the seventh schedule of the Indian constitution. The electricity (supply) act of 1948 was enforced with an objective of providing the rationalization of the production and supply of electricity, and generally for taking measures conducive to Electrical development. Under this act, the Central Electricity Authority (CEA) and the State Electricity Boards (SEBs) were formed. The SEBs were formed with an objective of providing power to the respective states. Central Electricity Regulatory Commission was formed in 1999 which emphasized on the participation of private sector in power generation.

Now, after 72 years of independence, India has increased its installed capacity to of 356.817 GW as of 31 May 2019 compared to 1,362 MW in 1947. India has emerged as the world's third largest producer and third largest consumer of electricity [1]. Conceptually there are two ways in which power can be made available to the power striven corners of rural India. The first one is the extension of grid and the second one is the distributed generation utilizing renewable sources. Until recently, the first one was the only option available for providing power. Indian government's first sincere attempt to explore the renewable sector came with the formation of the Ministry of Non-Conventional Energy Sources in 2003 which has been now renamed as the Ministry of New and Renewable Energy (MNRE) [2]. This ministry was formed with the sole objective of exploring the renewable energy potential of India. It started the Remote Village Electrification (RVE) program which aimed to

provide electricity to those far remote areas where grid extension is not a possible solution, utilizing renewable distributed generation. Under the twelfth five year plan, government launched the Rajiv Gandhi Grameen Viduytikaran Yojana (RGGVY) which aimed to provide electricity to all rural households. The Scheme is funded 90% by Central government and 10% by Rural Electrification Corporation (REC). With the new government taking over under the leadership of Narendra Modi in 2014 it tried to accelerate the process of village electrification. To achieve that, it proposed a new scheme called Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY). It replaced the previous scheme Rajiv Gandhi Grameen Viduytikaran Yojana (RGGVY). With an investment of ₹756 billion it aimed to electrify all villages of India by May 2018. The scheme was termed as a huge success of the government as it achieved its target even before its deadline with the electrification of Leisang village in Manipur. Even though the government claims that each one of the country's villages is now electrified, if we check the ground reality, it shows a completely different picture. There are still millions of households in rural India that do not has access to electricity and even if it does, there are issues of power cut and poor power quality. This mismatch is happening because the as per the definition set by the government, a village is called electrified if a minimum of 10% of its households or public institutions has access to the national grid. This means that a village will be electrified even if 90% of its households do not have electricity. This mismatch is a serious cause of concern and a topic for debate. Another problem with the rural population is that most of the families are unable to pay the electricity charges. There is a sufficient amount of expenditure in making power available to these areas by the grid and until and unless government subsidy is not there it becomes impossible for the power utilities to provide power to these people at a cheap rate. The government is committed to shift towards the renewable sources. India has a total installed capacity of renewable resources 75.06 GW as per the data in February 2019. India has emerged as a most promising market for investing in renewable energy sector for foreign investors. Total FDI inflow in this domain during the period 2000-2018 is around 14.42 billion U.S. dollar. The government's target of installing 175 GW of renewable energy includes the target of 100 MW of solar power, 60MW for wind power and other for mini/micro hydro, biomass etc. Some recent initiative by the Government of India to boost up the renewable energy sector are mentioned below:[3]

- Setting up of the world's largest solar power plant in Kumuthi, Tamil Nadu which is spread over an area of 2500 acres with an installed capacity of 648 MW
- Starting of inter-state distribution of wind power from August 2018
- A new hydro-power policy drafted for the growth of hydro-power sector of the country for the period of (2018-2028)

- Increased effort by the Indian Railways to depend more on green sources of energy.
- MNRE's decision to provide custom and excise duty benefits to those installing solar rooftops.

If such sincere attempts are continued in the coming future, India will soon emerge as one of the largest hubs of sustainable energy in the entire world. Apart from giving access to quality power and protecting the environment, it will also bring ample opportunities of employment which will strengthen its economy thus making the lives of its people far better[4].

IV. PRESENT SCENARIO OF RENEWABLE DISTRIBUTED GENERATION IN RURAL INDIA

Renewable distributed generation can be a blessing to the power deprived rural community of India. Without posing a threat to the environment, they can contribute efficiently to improve the living standards of the people living in the far remote location outside the reach of traditional grid. It can contribute as a backup source of power for those who are facing frequent power cuts and poor power quality. It offers opportunities of investment and earning revenue. Keeping this in mind, sincere attempts has been made from both the private firms and government sectors penetrate the rural India with renewable DG[5].

TABLE 1 Total renewable installed capacity in the last five years

FY	2014-2015	2015-2016	2016-2017	2017-2018
CAPACITY (GW)	33.79	33.8	50.07	73.35

Table 1 shows continuous improvement in the renewable energy installed capacity in the last four financial years. Let us discuss the present status of implementation of renewable distribution in rural India taking one type of source at a time.

A. Solar

For a country like India with a huge landmass and yearly incident solar radiation of 1200 to 2300 kWh/m², solar PV is the most dominant technology among the options for renewable sources. [6] In fact India receives more solar radiation than countries like U.K. and Germany. Solar PV suffers from the limitation of low efficiency(around 20%) and high capital cost (due to high price of the panel). Despite these limitations, the MNRE is very optimistic about harvesting the solar power which is abundantly available across the country. Solar PVs have a wide variety of applications starting from solar home systems, solar power plants, solar lamp, solar cooker, solar lanterns etc. These technologies have already penetrated into a large number of rural households. Solar home systems if provided with a

storage and an inverter becomes a very reliable alternative to the traditional utility grid.

B. Small hydro

These are generally run-off river projects contributing mostly to the rural communities living in the hilly areas of the country. These are cheap, localized and reliable options for these communities[7]. Small hydro power generation enjoys many advantages including minimum operating and maintenance cost, high capacity factor than solar and wind power, highest life-time and high efficiency (70-90%). Presently most of the small hydro plants are concentrated on the mountainous rural areas of northern India. According to the website of MNRE, India has an estimated potential of 20,000 MW of small hydro power plants. Despite its various advantages, the growth in the installed capacity of hydropower has been the slowest if we compare with that of solar and wind power. This is because of certain issues like problems in land acquisition, uncertainty of the final cost, prolonged time of completion etc.

C. Wind Power

Wind power is another source of energy gaining popularity recently. Southern India is considered as the hub of wind power. For the financial year 2018-2019, India has 36.625 GW installed capacity of wind power making it fourth largest wind power installed capacity in the world after China, U.S. and Germany. MNRE has set up target to increase the installed capacity up to 60,000 MW by 2022. Since the power generated by the wind turbine is directly dependent on the speed of the wind, hence it becomes highly unpredictable. Wind energy systems are mostly grid connected. It can also be employed along with diesel generator, solar or biomass to increase its efficiency. Minimum wind speed necessary to generate power from the wind turbine is around 12kmph. So wind turbines cannot be installed in areas with wind speed lower than this.

D. Biomass

Energy generation from biomass is perhaps the least implemented sector in development of renewable energy sources. Recently, MNRE is taking up several projects to encourage research in this area. Biomass produces energy from plant and animal waste through different combustion methods like Gasification, Pyrolysis, Combustion etc. Biofuel can be produced from animal and plant waste through anaerobical digestion. These wastes include crop waste, leaf waste, kitchen waste, sugarcane and wood waste etc. These waste materials are abundantly available across rural India. 12.83% of India's total renewable power generation is using biomass which amounts to a capacity of 17,500 MW. A large amount of rural population is still not aware of biomass and dispose their wastes in an unorganized manner[8].

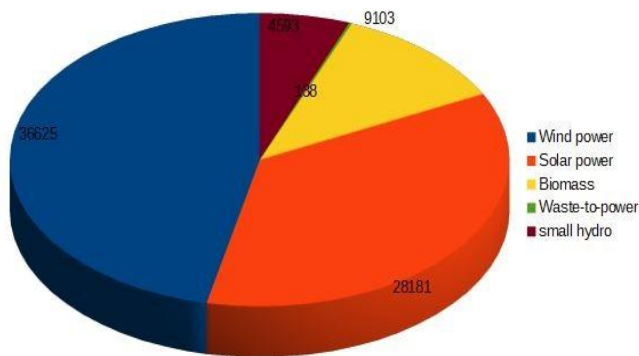


Figure 1. Installed renewable power capacity of India as of 31 March 2019

V. CHALLENGES AHEAD FOR RENEWABLE DISTRIBUTED GENERATION

Analysis of the challenges associated with distributed generation can be done from two different perspective; one is economic factors and the other one is the technology requirement. When we say renewable distributed generation, we are taking into consideration both off grid and grid connected sources. The standalone solar home systems with no connectivity to the grid is a reliable source of power as long as the load is limited within its capacity. Reliability can be improved if we shift from the standalone solar systems towards microgrids. Microgrids may consist of more than one type of source (solar, wind, small hydro etc.) and can be operated on both grid integrated or islanded condition. Here we discuss the challenges faced by renewable energy sector in India[9].

A. Low cost

The energy cost of solar home systems are approximately Rs 37/kWh Cost of such a microgrid system is around Rs 23-33/kWh depending on the type of generation source. It is worthwhile to mention here that the cost of traditional grid connected power is around Rs 3-4/kWh which means that higher cost is a big challenge in case of renewables. [rural energy alternativ]

B. Selection of appropriate system

Sometimes selection of appropriate system becomes crucial. The lifetime of a microgrid is around 15-25 years. If within this period the grid arrives to the locality, the local people will obviously move toward the cheaper option, the grid supply. If there is no policy for the grid to buy that amount of renewable power, then the investors will undergo a huge financial loss. There for it is better to invest in renewable sources only in those areas where the future arrival of the grid is very unlikely.

C. Poor economic condition of people

People residing in the rural part of India have a poor living standard. Their load demand is also low. One particular home generally has a demand less than 1kW. They are financially not capable to invest in such energy schemes. There is also lack of knowledge, ignorance and hesitation. Until and unless the rural community does not take active participation in the renewable power distribution, the projects cannot be 100% successful. Proper education and training is necessary for this.

D. Requirement of costly equipment

Proper harvesting and supplying of renewable energy in a reliable manner requires a lot of technical support. The solar panels, wind turbines, storage options, power electronic converters required for grid integration are costly and sophisticated. Trained personnel are required to handle these. Also, renewable technologies need a certain payback period to be able to give back profit to the investors. Most of the private firms, banks and other investors do not have proper knowledge of the benefits of such systems and are reluctant to invest in this sector. This mind set has to be changed.

E. Policy making issues

Sometimes the state run utilities are hesitant towards allowing renewable projects in their area of operation. They think this to be a threat to the traditional grid extension. Fixed protocols should be there for integrating such renewable sources with the grid so that there will be both side profit. The government of India is providing various financial assistance to boost up investment in renewable sector which will benefit our rural population in the long run[10].

CONCLUSION

In this paper we have discussed extensively the potential of renewable distributed generation in rural India to curb the problem of poor power quality and reliability. We have seen that distributed generation can be employed in two modes one is grid integrated mode and other is islanded mode. While the isolated mode is sufficient to supply limited load of a rural household, grid integrated mode offers additional advantage of reliability, security and load growth. We discuss the government initiatives taken till now to boost up the renewable energy installed capacity. A few challenges are still need to overcome and we are quite sure these will get solved soon to bring a significant change in the living standards of people living in rural India.

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