Decentralized Power Generation using Renewable Energy Resources: Scope, Relevance and Application

Khushboo Shekhawat, Devendra Kumar Doda, Abhishek Kumar Gupta, Mahesh Bundele

Abstract: ***Decentralized energy model successfully helps rural villages when it comes to supply of electricity because it's a schematic way of utilization of renewable resources with decrease in the amount of GHG emissions whereas national electricity grid does not provide a solution to the problems faced by rural areas. Renewable energy sources can be use as standalone or in a combination of different resources like solar photovoltaic, biogas system, biomass system, micro-hydro and wind turbines known as hybrid renewable energy system (HRES) with a diesel generator as per the load demand and availability of the resources, which also protects our earth by remarkably decreasing the pollution caused by carbon emissions that we produce. The paper presents a review of various case studies on off-grid electricity generation which can be distinguished on the parameters like Cost of energy (COE), Net present cost (NPC), Levelized cost of energy (LCOE), Levelized unit electricity cost (LUEC), Per unit electricity cost (PUEC) and Life cycle cost (LCC) with respect to grid-connected systems and extension of grid. The paper also details the different initiatives taken by the government of Rajasthan to encourage off-grid generation in Rajasthan.***

The main motive of this work is to present an efficient hybrid technology combination from a blend of renewable energy resources for electricity generation to meet the electrical need of an off-grid village which is cost-efficient, sustainable, techno-economically feasible and environment friendly

Keywords: Decentralised Energy Generation; Hybrid Optimization Model for Electric Renewables: Hybrid Renewable Energy System (HRES).

INTRODUCTION

In India, Maharashtra state is the leading generator of electricity. The energy consumption has risen by an average of 3.6 percentage per annum for last 30 years resulting to which India has become the world sixth highest energy consumer accounting to global energy consumption of about 3.4% [1]. The per capita amount of energy used is 1149 KWh and installed power generation capacity of India is 344002 MW by March 2018 [2]. We have relied more on burning fossil fuels to generate energy, which is a finite resource. As the consumption of conventional fuel is increasing, there is hike in fuel prices and also leads to GHG emissions and pollutants in air and water. There are certain scantly populated areas having very low power demands and are not supported by the national grids because of geographical isolation, rise in cost and distant locations [3]. Even if transmission lines pass through villages, they remain off grid due to lack of infrastructure required such as feeders and stations. Recently government has announced 100% electrification of villages, but this is also not free from its criticism. The government has taken village as a unit whereas there are still about 32 million households which remain in dark. There are doubts about the government data where one field report by India Today claims that there are several villages which are electrified only on paper. The India Today reported several villages in India to be without electricity, to name a few village Alirajpur- Madhya Pradesh, village Saprum-Jharkhand, Ghuraiya Hera, Hathiyakhar, Kehri ka Nagla and Rajghat-Rajasthan. Other challenge even for electrified households is to provide reliable and unhindered supply of electricity. Other challenge even for electrified households is to provide reliable and unhindered supply of electricity. The best solution to provide reliable, cost effective and environment sound energy is by off grid electricity generation using hybrid renewable energy resources. Sustainable energy sources like biomass system, solar photovoltaic, biogas, micro hydro and wind turbines are unlimited resources, inexhaustible former environment friendly and sustainable sources these energies can be used as standalone or in combination of these resources with diesel generator as per the load demand. There are several benefits usage of Renewable Sources like electricity generation, irrigation, cooking and preserving food, cooling, grain and milling processing, and in small industries. The various case studies are reviewed related to the need for electricity in rural areas, benefits of decentralized energy generation, hybrid renewable energy system to fulfil household needs, to light up rural lives by off-grid electricity generation and by employment opportunities to local youth etc. which are optimised with the help of different software like HOMER, LINDO, HYPORA, VIPOR etc. and with goal or linear programming approaches. The electricity scenario of India is also discussed and graphically presented with the main focus on the state Rajasthan.

Electricity Scenario in India

At the time of independence, total power generation was only 4073 GWh and coal/lignite, hydro and diesel were major source of generation due to its abundance in nature but there was negligible growth in the

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field of renewable energy generation. Total power generated in the year 2001(End of the 9th plan) was 517439 GWh which has increased drastically to 1235358 GWh in 2017(End of the 12th plan) which is almost 2.5 times of the prior. With the increase in power demand, generation by renewable sources has also increased to 81548 GWh in 2016-17. It can be said that various methods of power generation were employed during this time period to satisfy the increasing demand of power. The installed solar capacity of India is 3GW which was raised by almost 1GW in 2014. This results in only 1% India's total installed capacity of 260 GW (as of January 2015). If somehow in 2022, India gains its 100GW solar target it would still meet only 10% of the country's energy requirement. A huge amount of solar power can be produced by small off-grid solar plants even in remote locations of the country because of the high amount of natural sunlight it receives throughout the year which helps the rural homes to fulfil their energy requirement [4].

Table1. Plan Wise Growth of Gross Electricity Generation in India in GWh [2]

S No.	During financial year ending with	Hydro	Thermal				Nuclear	RES	Total
			Coal	Gas	Diesel	Total			
1.	1947	2195	1733	0	144	1877	0	0	4073
2.	1950	2519	2587	0	200	2787	0	0	5106
3.	1955-56(End of the 1st Plan)	4295	5367	0	233	5600	0	0	9662
4.	1960-61(End of the 2nd Plan)	7837	9100	0	368	9468	0	0	16937
5.	1965-66(End of the 3rd Plan)	15225	17765	69	324	18158	0	0	32990
6.	1968-69(End of the 3 Annual Plans)	20723	26711	124	194	27029	0	0	47434
7.	1973-74(End of the 4th Plan)	28972	34853	343	125	35321	2396	0	66689
8.	1978-79(End of the 5th Plan)	47159	52024	515	55	52594	2770	0	102523
9.	1979-80(End of the Annual Plan)	45478	55720	500	53	56273	2876	0	104627
10.	1984-85(End of the 6th Plan)	53948	96957	1834	45	98836	4075	0	156859
11.	1989-90(End of the 7th Plan)	62116	172643	5862	85	178690	4625	6	245438
12.	1991-92(End of the 2 Annual Plans)	72757	197163	11450	95	208708	5525	38	287029
13.	1996-97(End of the 8th Plan)	68901	289378	26985	679	317042	9071	876	395889
14.	2001-02(End of the 9th Plan)	73579	370884	47099	4317	422300	19475	2085	517439
15.	2006-07(End of the 10th Plan)	113502	461794	64157	2539	528490	18802	9860	670654
16.	2011-12(End of the 11th Plan)	130511	612497	93281	2549	708427	32287	51226	922451
17.	2016-17(End of the 12th Plan)	122378	944022	49094	401	993516	37916	81548	1235358
18.	2017-18	126123	986591	50208	386	1037184	38346	101839	1303493

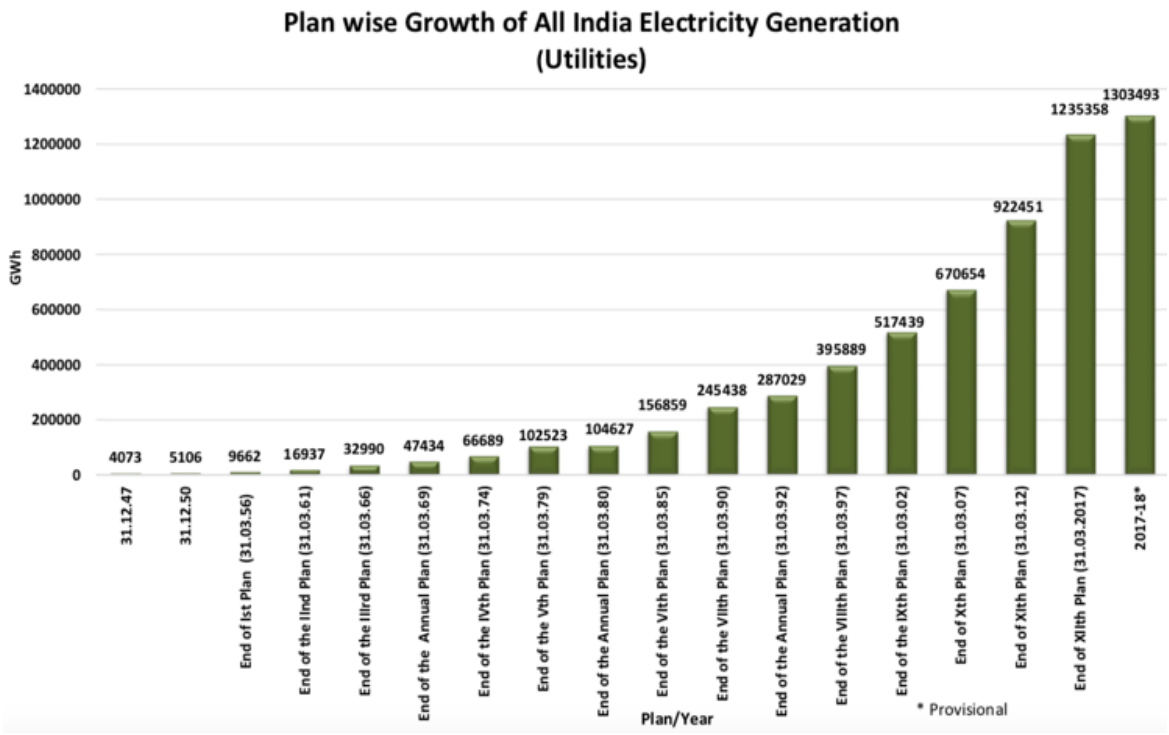

Fig.1 Plan Wise Growth of Gross Electricity Generation in India in GWh

According to the recent data by Central Electricity Authority, contribution of energy by different sources like coal, nuclear, hydro, gas, diesel and renewable energy sources are 57.32%, 1.97% ,13.17%, 7.24%, 0.24% and 20.06% respectively

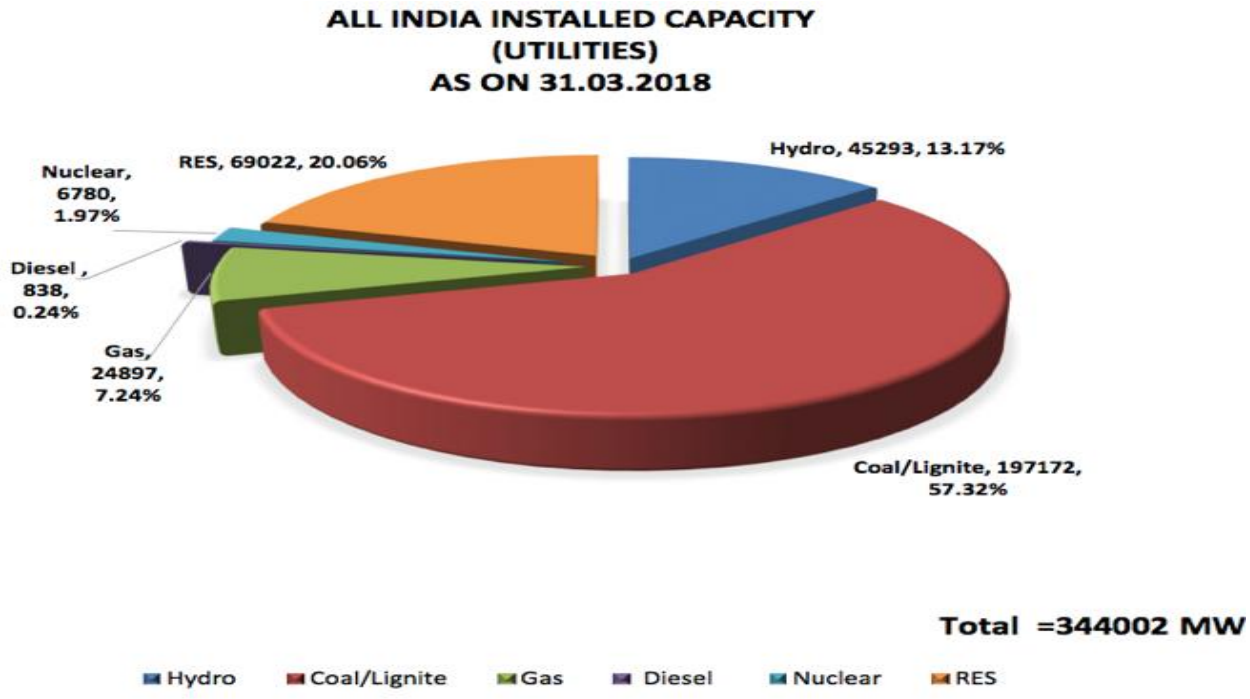

Fig. 2 Generation of Electricity in India [2]

The government has set the target of 100 GW from solar power, of that 40 GW is to be generated from rooftop panels. By Dec, 2018 only 6% of the target, i.e. 2.5 GW was produced from rooftop panels.

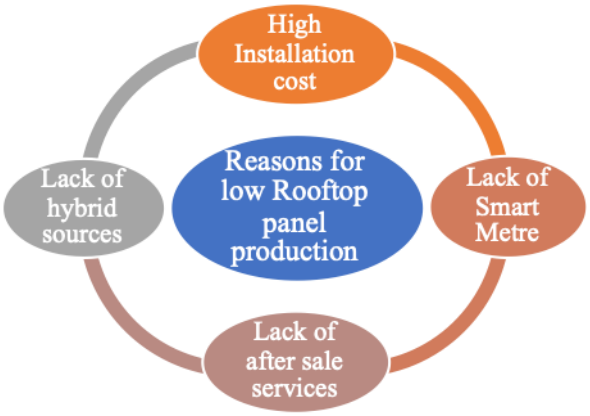

Fig.3 Reason for Low Rooftop Panel Production

The major hindrances like high installation cost and lack of hybrid sources of renewable energy can be resolved by government policy initiatives.

- First of all there is need to reduce cost of production of PV cells. One way is to reduce 25% safeguard tariff imposed on Chinese and Malaysian PV cells.
- Other is to promote off grid energy generation by hybrid sources of renewable energy.
- Subsidizing smart meter so that households can sell back extra energy produced to the grid.

B. Renewable Energy Resources

a. Solar Energy Source:

Earth receives energy from the Sun and is renewable. Almost all the energy forms used in Electrical power generation are of solar origin. This has been an ongoing process since the ancient times and later with the development of science and technology, advancements were made in the field of energy conversion. Concentrated solar have been another technology used time and again to produce solar power through mirrors or lenses to focus a large area of sunlight into smaller zones. One of the most important achievement in the use of solar energy was the photovoltaics which involves direct conversion of electromagnetic radiation as sunlight into electrical energy. The solar energy which is harnessed by this technology is further used to generate electric energy for consumption in residential, commercial, as well as commercial sectors. Hence this permanent inventions and innovations in the field resulted in increased of efficiency, the size of production, environmentally sound energy and also lead to cost reduction making it an important and integral part of the human society. It was announced as 100 GW of solar energy generation by the government of India and also targeting an investment of US$100 billion by 2022. Total installed capacity of solar energy generation is 29.41 GW as of May 2019.

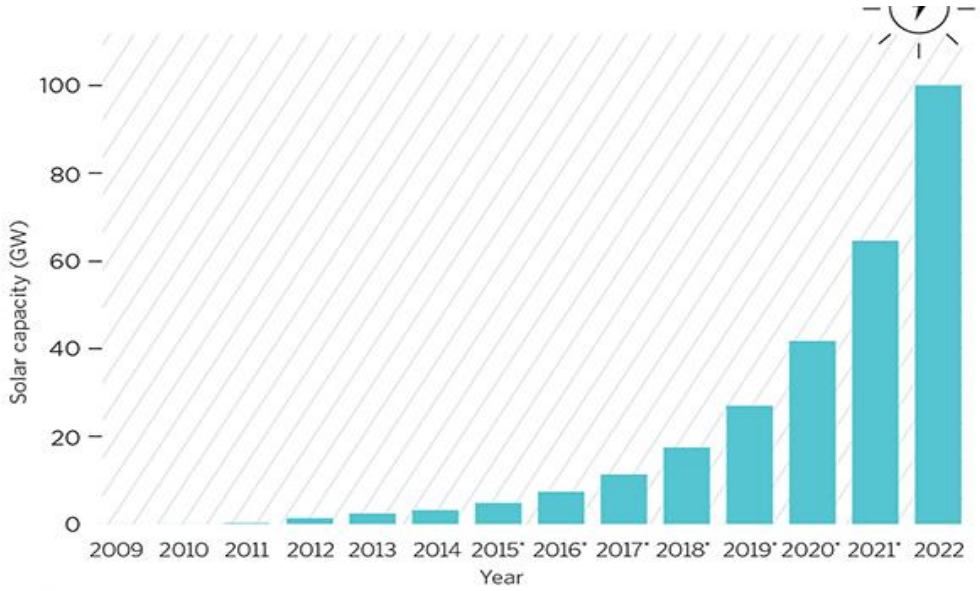

Fig. 4 Solar Energy Generation Target of India [4]

b. Wind Energy Source:

Wind energy system is also a great option for off-grid renewable energy generation. In winters the winds are fast moving in the evening hours that's why it uses in combination with solar energy systems which are relatively more available in summers. The power in the wind is a cubic function of wind speed. The device used to measure the speed of wind is anemometer. The proper positioning of the wind turbine is required to enhance its performance. Metrological data rely on environment, economical, technological, social and political parameters having major impression for selection of components and estimation of wind-based systems. By considering hub height, wind speed and law components of power as constrain parameters, an accessible simulation model can be developed using wind generation system. The government of India has also targeted to increase the wind power capacity to 60GW by 2022 which is 34.9 GW in 2018[5].

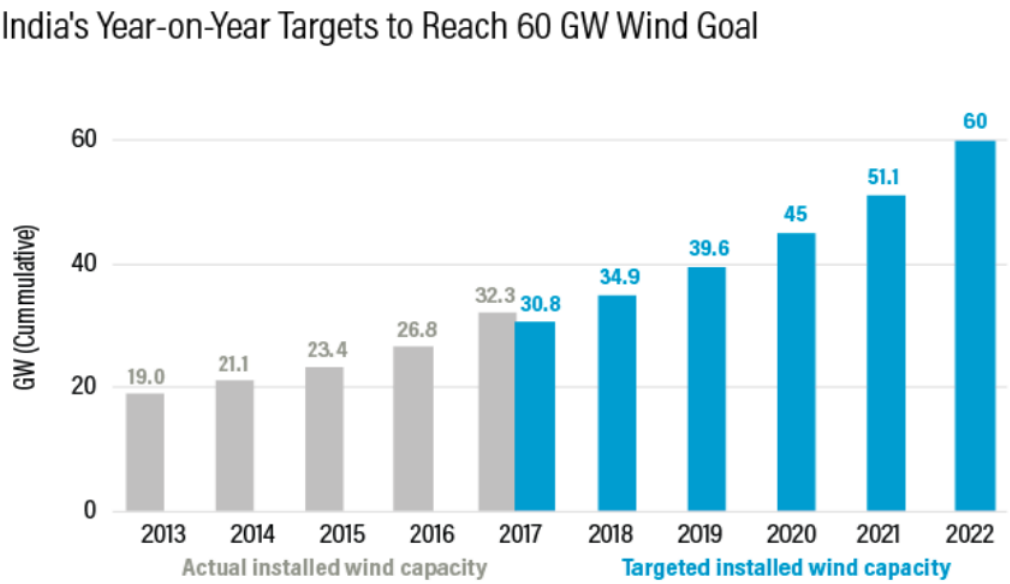

Fig. 5 Wind Energy Generation Target of India [5]

***c. Biomass Energy Source*:**

Biomass is a renewable source of energy and contributes 2.632 GW share in total energy generation in India. It is extracted from animal excretion and plants waste. The energy receives and stored from the sun is known as Biomass. A process in which the sun's energy stores in plants is known as Photosynthesis, the chemical energy is released as heat when biomass is burned. Some of the biomass are agricultural crops and waste materials, wood and wood processing waste, food and yard garbage, human sewage and animal manure etc. Biomass energy system can be used along with solar and wind energy systems according to the demand and availability of resources.

II. ELECTRICITY SCENARIO IN RAJASTHAN

Rajasthan is the fastest growing state in the development of renewable energy generation with solar power installation capacity of 2,280 MW as on March 2018. In total 10% of the power is being contributed by the solar power generators and it is estimated to gain a hike of 17% by 2021. It is soon going to unveil a few more important projects of 1,500 MW which may lead to the betterment of the state. The generation of solar power energy may increase by 3,780 MW till the end of year 2020 and also planning to accomplish the target of 7,000 MW in the upcoming years. Other than solar energy Rajasthan is also spreading its wings in the sector of wind by generating 4,292.54 MW and in biomass by generating 120.45 MW.

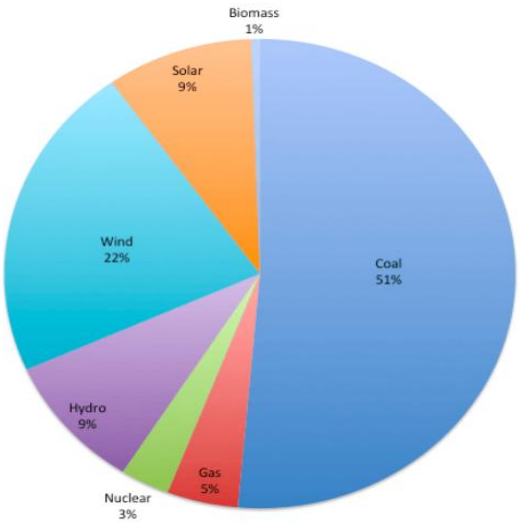

Fig.6 Energy Generation scenario in Rajasthan [20]

Successful initiatives of renewable power generation in Rajasthan

Following section briefly present the case studies of different renewable energy based decentralised power generation initiatives in the state Rajasthan.

a. Bhadla solar park

Bhadla Solar Park is one of the largest solar parks in India which is spread over a total area of 10,000 acres (40 km^2) in Bhadla, Phalodi tehsil, Jodhpur district, Rajasthan, India. The park will have ultimate capacity of 2,255 MW[6]-[25]. The park has witnessed one of the lowest bids for tariff of Rs2.44 per kWh, which is lowest for solar in India so far. Acme Solar announced that it had commissioned India's cheapest solar power in September 2018, 200 MW at Bhadla[6]. Avada Energy, Acme Solar and SoftBank have commissioned 60 MW, 200

MW and 360 MW, respectively. The remaining 880 MW, to be installed by Hero (300 MW), Azure (200 MW), SoftBank (200 MW) and ReNew Power (50 MW), is scheduled to be commissioned by March 2019[6]-[25]. Currently, solar accounts for 10% to the state's total power consumption. The goal is to reach 17% by 2021.

Table.2 Bhadla Solar Park Plant Detail

Plant capacity :	2255 MW
Tariff :	Rs2.62 per unit
Total area :	10,000 acres (40 km^2)
Average temperature:	46 and 48 degrees Celsius
Location :	Bhadla, Jodhpur district, Rajasthan, India
Commission date :	22 Feb 2017
Type:	Flat panel PV
Unit operational :	1515 MW
Unit under construction :	740 MW

b. Jaisalmer Wind Park

India's 2nd largest onshore wind farm is Jaisalmer Wind Park situated in Jaisalmer district, Rajasthan. This project was launched in August 2001 established by Suzlon Energy and comprises of Suzlon's entire wind portfolio – ranging from the earliest 350 kW model to the latest S9X – 2.1 MW series [7]. It is world's largest operational onshore wind farms because of its installed capacity, which is 1,064 MW. Combined installed capacity was 1064 MW at the end of FY12. This performance makes the wind park the 2nd largest of its kind in India, and one of the largest wind farms in the world. With the successful installation of the first 2 MW demonstration project at Amarsagar, Jaisalmer district where 8 wind machines of Nordex (BHEL) at a 40 metre hub height were installed (each of 250 kW capacity), the dream of generating electricity through wind power came true [26]. In the year 2000, the second demonstration project of 2.25 MW total capacity with 3 NEG Micon wind machines of each of 750 kW was established at Devgarh district in Chittorgarh (now in district Pratapgarh). The hub height at this wind farm was 55 metres. The third demo project with a total capacity 2.10 MW with 6 Suzlon machines each of 350 kW capacity was set up at Phalodi district in Jodhpur [26].

Table.3 Jaisalmer Wind Park Plant Detail

Plant capacity:	1064 MW
Location :	Amarsagar, Amarsagar-Badabaug-Tejuva-Soda Mada, Jaisalmer district, Rajasthan
Type:	Onshore
Commission date :	2001
Unit operational :	Suzlon's entire portfolio ranging from 350 kW model to S9X – 2.1 MW series

c. Barefoot college, Tilonia:

The Social Work And Research Center (Tilonia, Rajasthan) also known as barefoot college is entirely solar electrified college and managed by rural people There are currently over 2200 illiterate women proficient in designing, installing and maintaining solar systems that provide light and electricity to their villages (they are known as "Barefoot Solar Engineers). The barefoot engineers have been bringing light to rural households for last many years. There are 18,047 households which are already installed with solar panels. The barefoot operates in 13,00 villages in 80 countries worldwide and has provide light to 1000000 people. Rural women built solar electrification systems at college (e.g. LED lamps, charge controllers, Home lightning systems, Solar lanterns, Solar water heaters, Solar powered water desalination and Parabolic solar cookers).

Un-electrified villages in Rajasthan

Rajasthan is slowly and steadily moving forward electrifying the rural areas which still remains un-electrified According to the statics there are still back laid households in Rajasthan which do not have any power supply but are expected to be electrified within the coming years. Using the facility of off-grid solar panel system many villages in isolated areas of the state have been provided with electricity and other renewable resources, in the coming years a few hamlets will also be given the same resources. India Today claims that there are several villages which are electrified only on paper and reported several villages in Dholpur (Raj) to be without electricity, to name a few Ghuraiya Hera, Hathiyakhar, Kehri ka Nagla and Rajghat.

III. LITERATURE REVIEW

The various case studies of on-site generation related to the need for electricity in rural areas, benefits of decentralized energy generation, cost of generating energy, hybrid renewable energy system to fulfil household needs, to light up rural lives by off-grid electricity generation and by employment opportunities to local youth using hybrid inexhaustible energy sources and optimized by several software are reviewed, with the main emphasis on the state Rajasthan. Akash Kumar Shukla et al. [1] this research is imprinted with solar energy potential in India. Government of India has introduced many policies, schemes and incentives to motivate industries and individual to utilize solar energy through solar PV and BIPV. This drives economic growth, ensures power security, reduces GHG emissions and some of the BIPV also commits a reduction in CO2 emissions. The study also reported two states of India, Gujarat and Rajasthan with the setup of solar PV capacity of almost 919 MW and 738 MW respectively are the leading solar photovoltaics states of India. Researcher also discussed straight up space in buildings can be efficiently used BIPV technology for such as facades, other building integrated applications by fitting translucent and semi-translucent solar PV modules and windows, however India still has many barriers in the field of BIPV installation like shortage of learned engineers, less interest shown by user because of its rates and high payback that's why the government should motivate to encourage BIPV research and promote investments to boost cost reduction and financial growth. A.K. Akella et al. [3].

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In the paper an IRES for 12 un-electrified villages of Jaunpur block, district Tehri Garhwal, had been taken for fulfilling their energy need of 808 MWh/yr. load consisting SPV, MHP, WES and BES contribute total energy demand of 2.27%, 16.81%, 1.78% and 79.14% respectively which is optimized through LINDO software 6.10 version [3]. The best outcome obtained using the previous conclusions are also proven using Tora software and the relative outcome of LINDO along with HOMER software are also shown. The amount of energy consumed by LINDO software is lesser than that of HOMER software and indicates that the system can give practical results specifically with EPDF 1.0–0.75 or else it becomes impractical [3]. The feasibility study shows that the IRES is the most appropriate and relevant system for any back laid area J. Vishnupriyan et al. [8]. The motivation of the paper is to develop a standalone hybrid power system and five radiation models for GSR estimation. The radiation models are linear, second order polynomial, third order polynomial, exponential and power series models with input parameter of bright sunshine duration [8]. It has been taken in notice at Madurai that the two input models show excellent estimation and also applied to six locations with different climatic conditions in India. To calculate the daily GSR of other climatic locations, to achieve the generalized Sa/So values of Madurai of all month. The mean percentage error may come in between 1.1198% and 15.3547%. Bibhu Prasad Ganthia et al. [9] mentioned that the technical and economic factors of a power plant, load estimation of village and calculation of total cost per unit generation for solar PV, biomass and biogas i.e. Rs4.5350, Rs1.972 and Rs2.009 respectively, to meet the basic electricity need of Khalardda village in Odisha. The cost of generation is calculated as Rs4/kWh with a hybrid system which is comparatively lesser than minimum per unit tariff of Rs5.50/kWh by grid connection. Estimated calculations are shown for study area only which is neither designed nor optimized by software or programming model. Sayedus salehin et al. [10]. This paper has illustrated two energy software tools one of which is HOMER, used for optimization and is also used to calculate the amount of energy consumed by the renewable energy system and the second one is RET Screen which gives elaborated financial and emission survey. This paper is basically assessed for two diesel energy systems one is solar PV and the other is Wind in Kutubia Island, Bangladesh to content the peak load requirement of 37kW with 10% per annum interest rate and has considered lifetime of 20 years of the plant. In the first model ,62kW PV-array had produced 88% of electricity and rest 12% with a 9kW diesel generator and cost of energy was $0.353/kWh, whereas 81% of electricity was by 17 wind turbines (51kW) and 19% by diesel generator with $0.487/kWh COE in the second model. For both the models RET Screen was used and calculated 5.4 years and 11.2 years equity payback period with $234,267 and $347,859 initial cost whereas per annum GHG emission deduction of 54.3tCO2 and 42.9tCO2 respectively. It has been concluded from the simulation results that the minimal cost of energy and payback period is achieved from the solar-PV diesel system. Rohit Sen et al. [11] in the paper best suitable combination of a hybrid renewable resource for off-grid electricity generation is simulated with PV array, SHP, BDG, Inverter, Rectifier and batteries in Palari village, Chhattisgarh by HOMER software. The load demand has observed 222kWh/ day and 51.2 kW peak, 212kWh/day and 39.4kW peak, and 58.6kWh/day and 68.6kW peak for primary load 1, primary load 2 and deferred load respectively [11]. Cost of energy is found to be $0.420/kWh which is cost efficient than $0.44/kWh of grid extension. The total net present cost and capital cost are evaluated as $673,147 and $238,000 respectively. The main advantage is small hydropower plant serves as a cost cutting process of power to the rural areas but it is infeasible to pay the high cost of energy for the villagers. Md. Mizanur Rahman et al. [12] has suggested that according to the HOMER simulations that the cooking and electric load are being fulfilled by the system of solar resource and biogas. The household can save up to worth 309 US$,381 US$ and 412 US$ per year against annualized costs of 282 US$,344US$ and 394US$ by inheriting new technologies for HHC1, HHC2 and HHC3 respectively [12]. 73% of the standard household were adoptive toward the biogas plant facilities. The main limitation is that people cannot meet their cooking demands because of standalone solar PV system [12]. Muyiwa S. Adaramola et al. [13**]** in this paper, a study carried out in backlaid and semi-urban locations of the northern region of Nigeria to access electricity by PV/Generator/battery hybrid energy system. The most approachable option for the residential and commercial users that intake a huge amount of electricity is the hybrid energy system suggested in this study. It has found by simulating on HOMER software, in hybrid energy system levelized cost of energy flicker between $0.348/kWh to $0.378/kWh which is effectively lesser than using a specifically diesel-based energy system which varies from $0.417/kWh to $0.423/kWh and also decreases GHG emissions [13]. It was noticed that the current electricity tariff for low consumption users was much lesser than the cost of electricity by hybrid system It can be reduced by minimizing the rate of interest for organization or colonies keen towards the growth of hybrid energy systems. U. Suresh Kumar et al. [14] the researcher has found the optimal cost of energy 0.2345$/kWh which is cheaper than that of all combinations using hybrid renewable energy system simulated on HOMER software. The total capital cost is $920,000, total operating cost is $86,279 per year and the total net present cost is $2,022,938 for annual consumption of 1.989kWh/d and 207kW peak load in Mandapam, Tamil Nadu by considering 2000kW solar PV, wind generator, a battery of 10 number and 10,000kW converter. Effective cost is achieved by utilizing the benefits of wind generation. M. Millinger et al. [15] In this paper the survey is based on the investigation of 11 villages in the district of Bilaspur and Jagdalpur in Chhattisgarh by the recommendation of CREDA, which includes question regarding appliances used, habits, general household information, energy use, own perception on benefits and household economy mainly focused on changes for women. This has been found that children have 41 minutes more for studies in the evenings which is two times more after electrification, supper is cooked near about 36 minutes later and the use of kerosene is reduced by two liters as per

the survey [15]. Commercial growth tasks were very bound in rural areas, plant capacity parameters were noticed to differ considerably, large pliability from MNRE is the option and growth of the worthy system based on a large importance on the social perspective of the technology and of the organization is therefore required. A.B Kanese-Patil et al. [16] The researcher has considered for different scenarios for off-grid electricity production from hybrid conventional energy sources to fulfil the electrical and cooking requirement in Almora district of Uttarakhand and found scenario for which is having 44.99 % MHP, 30.07% biomass , 5.19 % biogas and 4.16% solar energy along with additional resource of wind 1.27% and energy plantation 12.33% [16],the best option in terms of cost of energy optimum cost of the system and EIR i.e. Rs3.36/kWh , Rs19.44 lacs and 0.95 EIR using LINGO software version 10 [16]. In this research, COE is drastically reduced by the addition of energy plantation in scenario 4. All four scenarios are also compared an optimized in HOMER and the min cost of energy Rs5.90 is of scenario 4 including battery backup, which is higher than LINGO software optimization. Results of LINDO software can only be used for study area because the amount of converter, cost of batteries and local grid cost cannot be calculated by this software. Sanjoy Kumar Nandi et al. [17] developed the off-grid hybrid system simulated on HOMER software for Kutubdia, Bangladesh which devour 160 KW load with a 23KW peak load. It consists of wind turbines, PV modules, a diesel generator and a battery [17]. The cost of energy of different renewable option with 0% and 5% capacity of a shortage is plotted and analyzed. It is found from the analysis, the most suitable electricity generation option is wind –diesel hybrid system and is much more cost efficient than wind, wind-PV hybrid and PV alone system. This hybrid model reduces the fuel cost and 44% greenhouse gasses from the local atmosphere. Harsh Mohan Sharma et-al. [18] studied the various successful initiatives of decentralized power generation in India, with their cost of generating energy and optimization methods, some of papers are based on comparison of cost of
energy of decentralized system with grid connected system. Electricity scenario is discussed, by describing electricity generation, contribution of wind and solar energy for electricity generation, installed capacity of power plants and also presented survey data of an unelectrified villages in India and in Rajasthan [18]. By reviewing various papers, it has been concluded that the cost of energy lies between $0.348 to $0.378/kWh for solar PV, for wind cost of energy comes out to be $0.35/kWh, for biomass LUEC lies between Rs.20.34 to Rs.11.89/kWh and for micro hydro power LCOE found between $0.28 to $0.35/kWh [18]. Installation cost of decentralized system was high as compare to grid systems and it has been seen from the results that the output power by renewable resources is economical in terms of cost, availability and reliability.

IV. SOFTWARE DESCRIPTION

Mistaya Engineering was responsible for the creation of HOMER which is a micro power optimization software. They developed it keeping in mind National Renewable Energy Laboratory (NREL) USA. Designing, modelling and analyzing the optimal architecture and controlling strategy of the Hybrid Power System are the basis tools of this software. Distinguished economy and schematic analysis are some of the task performed by it using on-site power generation system to achieve the exact outcomes.

For every configured system HOMER went through the calculations of energy balance.

- It estimates the flow of energy for every component of the system from one point to the other and back for each.
- After that it verifies practicality of the configuration i.e. weather under a certain condition the electric demands can be achieved or not.
- Over the lifetime of the project, it evaluates the amount of installation and the systems operation.

The system with batteries or fuel-powered generators, HOMER also facilitates the working process for the generators and also decides whether to charge the batteries or not.

V. CONCLUSION & FUTURE SCOPE

A large potential of renewable resources is available in India due to which off-grid electrification is much preferred when it comes to lighting up the rural locations where extension of grid isn't possible because of economic constraints. Given below are some conclusions drawn from the reviewed papers:

- Decentralize power generation through a renewable source of energy for rural electrification not only offers a viable and long-term solution, but also a means for achieving development in underdeveloped areas, such organizations are - "DESI Power by DAWAG Switzerland and Development Alternatives" , "Barefoot college, Tilonia", "Avani,Uttaranchal", "NARI, Phaltan" etc.
- Cost of energy is found to be lesser than that of grid connection.
- Cost of installing decentralized systems are initially higher than grid system but can be compensate in long run.
- Transmission and distribution costs can be significantly reduced because electricity generation is at user end.
- By off-grid electricity generation, consumption of kerosene is also reduced and thereby avoiding health problems due to kerosene-based lightning.
- Solar lanterns are lighting up both youth and adult lives by providing employment opportunities, literacy centers and night schools [22]
- The foremost benefit of using renewable energy sources for electricity generation is reduction in greenhouse emissions.
- Effective cost can be achieved by taking advantages of wind, biomass, hydro plants along with solar plants.
- The perfect method to secure efficient and cost-effective electrification is by integrated expansion of centralized and decentralized electrification because this prevents from coordination failure. After discussing the various hybrid as well as standalone decentralize power
- generating energy sources, it has been found that small-scale power generating stations are additionally efficient and cost-cutting.

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- The round the clock supply of electricity is a major concern in rural areas even after 100% electrification of villages as claimed by government. Therefore, off-grid generation of electricity is the solution to the economic and qualitative issues faced by rural households.

Decentralised energy generation can be one of the major steps that can help thousands of rural lives. It will make them capable to participate in creating better identity for themselves. It is a way to teach the government, public and investors to wisely utilise the resources available around in the best possible way. It will have a positive impact by providing electricity in isolated villages which have not been exposed to electrical grid. With some scope of improvement, this research will come closer in reaching the ultimate goal that is creating an environmentally sustainable energy system.

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